UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLUMBIA

UNITED STATES OF AMERICA,	)	
	)	
Plaintiff,	)	Civil Action No. 99-CV-02496 (GK)
	)	
v.	)	
	)	
PHILIP MORRIS USA INC.,	)	Next scheduled appearance:
f/k/a PHILIP MORRIS INC, et al.,	)	Trial (ongoing)
	)	
Defendants.	)	
	)	

WRITTEN DIRECT EXAMINATION OF
DAVID E. TOWNSEND
SUBMITTED PURSUANT TO ORDER # 471A

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I. INTRODUCTION

Q. Would you please tell us your full name and where you live?

A. My name is David Eugene Townsend. I live in [DELETED]

Q. Briefly tell the Court about where you grew up, your wife and family.

A. I was born in Kansas City, but grew up in Charlotte, North Carolina. After college in North Carolina and Florida, I lived in New Jersey and Pennsylvania while working for a chemical company. I moved to [DELETED] in 1977 and have lived in that area ever since with my wife and two daughters.

Q. Are you currently employed, Dr. Townsend?

A. No, I just retired from R.J. Reynolds Tobacco Company ("Reynolds"), effective January 31, 2005.

Q. At the time of your retirement, what was your title?

A. I was the Executive Vice President of Research & Development for Reynolds.

Q. To whom did you last report in that role?

A. I reported to Lynn Beasley, who is currently the president and chief operating officer of Reynolds.

Q. Who replaced you as the head of Reynolds' Research and Development Department?

A. Dr. Jeffery Gentry.

Q. How long had you been employed by Reynolds?

A. For more than 27 years. I began working at Reynolds in October 1977.

Q. For how many of those 27 years were you involved in the research, design, and development of cigarettes?

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A. For the entire 27 years that I was at Reynolds, I spent my time and energy studying cigarette design, in either basic research or applied research. In particular, I was involved in trying to understand how cigarettes work and how to modify cigarettes to accomplish certain objectives, like potentially reducing the health risks of smoking.

Q. Do you understand that you have been designated by the Defendants to testify as an expert witness in this case?

A. Yes.

Q. Do you understand that you have also been identified as a fact witness to testify regarding matters within your personal knowledge and experience as an employee at Reynolds?

A. Yes.

II. EDUCATION, BACKGROUND AND QUALIFICATIONS

A. EDUCATION

Q. Dr. Townsend, before getting to your opinions in this case I would like to briefly review your background, experience and qualifications to present testimony to the Court. Please tell the Court about your formal education beginning with college.

A. I attended undergraduate school at the University of North Carolina at Chapel Hill from 1965 until 1969, where I received a Bachelor of Science degree in chemistry. I then attended Florida State University where, in 1972, I received a Master of Science degree in physical organic chemistry. I continued my studies at Florida State University and received my Ph.D. in physical organic chemistry in 1974.

Q. What does physical organic chemistry entail?

A. As its name implies, physical organic chemistry combines the fields of physical and organic chemistry. Organic chemistry is the study of organic molecules which are primarily

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composed of carbon and hydrogen. Organic molecules are the building blocks of most natural materials and products. Physical chemistry concerns the physical aspects of molecules, for example, how fast they react, and how their size and shape affect the types of reactions that occur. A physical organic chemist tries to understand such things as the shapes of organic molecules, how those molecules react with one another, and how particular properties of a compound may influence reaction rates.

Q. Did you apply the learning from your education to the research and design of cigarettes at Reynolds?

A. Yes.

B. EMPLOYMENT HISTORY

Q. After obtaining your Ph.D. from Florida State, what did you do?

A. After graduation, I worked for a chemical company called Rohm & Haas in Philadelphia, Pennsylvania.

Q. What did you do at Rohm & Haas?

A. I worked in process research, particularly dealing with molecules called monomers. They are compounds or molecules that ultimately can be made into polymers that are used in plastics such as Plexiglass and car finishes.

Q. How long did you work for Rohm & Haas?

A. I was there for a little over three years, from 1974 until 1977.

Q. What did you do after you left Rohm & Haas?

A. I accepted a job with Reynolds in Winston-Salem.

Q. Before you took the job with Reynolds, did you know that they made cigarettes?

A. Yes.

Q. Why did you go to work for a cigarette company?

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A. There were several reasons that I decided to work at Reynolds. The people that I saw and spoke with at Reynolds were smart and dedicated scientists. The research facilities were top notch.

Also, the physics and the chemistry inside of a burning cigarette is very complicated and, thus, I believed that trying to unravel that would be intellectually challenging. Finally, I could see ways, as many of the Reynolds scientists did, to apply the research on understanding the chemistry and physics of cigarettes to potentially reduce the risks of smoking.

Q. What was your title at Reynolds when you were hired?

A. When I was hired, my title was Senior R&D Chemist.

Q. What were your duties and responsibilities as a Senior R&D Chemist?

A. My first job was to plan and conduct experiments in the laboratory, particularly basic research in the area of cigarette design. I worked in the area of filtration and how to remove or reduce certain compounds from smoke. I devoted a lot of time to looking at carbon monoxide, nitrogen oxides, and other compounds and tried to understand how to modify cigarettes in order to reduce those compounds. As part of that project, I worked on cigarette paper, trying to determine how it can influence the production of different compounds in smoke. I also assessed various compounds that could be added to cigarette filters to attempt to reduce certain smoke compounds, like carbon monoxide.

Q. Were you promoted during your time with Reynolds?

A. Yes.

Q. Briefly describe the promotions that you received while you were employed at Reynolds.

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A. In 1984, I was promoted from Senior R&D Chemist to Master Scientist. At Reynolds, there is a dual ladder system for promotions where scientists can be promoted on a technical ladder separate from the management ladder. The technical ladder provides a way for scientists to progress up in the organization without going into management. The Master Scientist position is the first rung of that technical ladder. As a Master Scientist, I became more involved in planning research efforts and trying to decide the types of experiments that needed to be conducted to accomplish certain goals. In 1987, I was promoted to Principal Scientist, the next step up on the technical ladder, and I directed a small research group. In 1995, I was promoted to Senior Principal Scientist, which is the highest position on the technical ladder. In 1996, I was promoted to Director of Product Development. In 1997, I was promoted to Vice President of Product Development and in 2000, I was promoted to Executive Vice President of Research & Development. As I testified, I retired from that position on January 31, 2005.

Q. At the time you retired, within Reynolds' Research and Development Department, was there anyone above you?

A. No.

Q. What were your job duties as Executive Vice President of Reynolds' Research and Development Department?

A. I was responsible for all of the research and development activities for Reynolds, including product development, product testing, product stewardship, regulatory affairs and the R&D library.

Q. While employed at Reynolds did you continue to be trained and educated in scientific areas relating to cigarette design?

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A. Yes. My education, like that of anyone studying in a scientific discipline, taught me how to conduct research. But there is no specialized training that one can get at a college or university to study tobacco, cigarettes and cigarette smoke. The only way to obtain the specific skills necessary in the cigarette business is by on-the-job training. So I spent a lot of time, particularly early on in my career, going to the Reynolds R&D library, studying company research reports, and talking to scientists in other areas, all with the intent of trying to learn as much as I could. In addition, I attended scientific conferences to talk to other tobacco and cigarette researchers, to understand what types of experiments they were conducting, and to hear what directions they were taking. Also, to the extent possible, I tried to stay abreast of the literature relevant to my areas of expertise. All of this was an ongoing process throughout my career.

Q. What literature was relevant to your areas of expertise?

A. I reviewed reports and memoranda written by other Reynolds scientists regarding the research that they have conducted. I also reviewed publicly-available literature from scientists at other tobacco companies, at universities, within the government, and from the public health community.

Q. Why did you look at outside scientific literature?

A. To find out what the current state of science was. I believe that it is important to stay broadly educated and to look at what others are doing, not only in the tobacco industry, but also at universities and medical schools. It is important to understand what is occurring in biology and toxicology, to see what the developing theories are about why cigarette smoking is a serious health risk, and to understand what the developing theories are about what might be done to reduce the risks of smoking.

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I and other Reynolds' scientists looked at the external literature to see what our competitors were doing and to help us formulate our own research plans to keep up with them, and hopefully beat them, in the marketplace.

Q. Did you also look at publications that predated your employment with Reynolds, before 1977?

A. Yes.

Q. Why did you do that?

A. My job was to try to reduce the inherent health risks from cigarette smoking. In order to do that, I needed to research and understand the theories about how to reduce risk and the information that supported those theories. I needed to know about what scientific avenues have been pursued and which ones showed promise. To do my job, I needed to be informed on these issues and the science around them so that I could develop the best R&D program and conduct the best science possible.

Q. Have you also read the reports of the Surgeons General?

A. I am generally familiar with the Surgeon General's Reports and have read in greater detail the portions of many of them that relate to cigarette design.

Q. Do other scientists at Reynolds also look to the external scientific literature for ideas and suggestions?

A. Yes, to varying degrees, all of the scientists at Reynolds examine the scientific literature.

Q. You told us about your promotions while at Reynolds and how you made your way up the technical and management ladders. At what point did you became part of what you would consider upper management?

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A. I would say that I became a part of upper management when I was promoted to Director of Product Development in 1996. Certainly, I had some management responsibility before then, but that was not what I would call upper management.

Q. Up until your retirement in January of this year, did you remain in upper management?

A. Yes.

Q. During the 9 years that you were in upper management, from 1996 until your retirement in 2005, did the R&D Department have any role in providing information to the most senior executives with respect to smoking and health issues?

A. Yes.

Q. What has R&D's role been during these past 9 years?

A. The smoking and health issue is a scientific issue. Our executive management at Reynolds looks to R&D to understand what the state of the science is, what is known about the risks of smoking, and what is known about smoking and various specific diseases. One of the tasks at R&D is to update management about the state of the smoking and health issue.

Q. Over the past 9 years, did you personally participate in these updates with senior executives that you've described?

A. Yes.

Q. How often did these updates on smoking and health occur?

A. The meetings were mainly driven by the state of scientific knowledge. The meetings took place when there was new information from the scientific literature that may affect our understanding about the risks of smoking. In addition, meetings occurred if one of the executives had a particular question.

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Q. Let's return to the kinds of information that you've reviewed during your tenure. In addition to the external publications you mentioned, did your duties as a product developer require you to become familiar with Reynolds' efforts in cigarette design that predated your employment with the company?

A. Yes.

Q. Why?

A. We need to become familiar with the types of experiments that have been conducted, and what the successes and failures have been. We try to understand the past so that we do not repeat bad experiments, but rather can design better experiments and move toward achieving our goal of developing cigarettes with the potential to reduce risk.

Q. How did you go about educating yourself on the internal research and development efforts of Reynolds that predated you?

A. The first place I went was to the library within Reynolds' R&D Department. In addition to scientific journals, periodicals and books, our library includes the internal research reports and research memoranda from Reynolds' scientists. Also, our library houses the original laboratory notebooks that the scientists used to record the raw data from their research. So, if necessary, I could go from the research report back to the original laboratory notebook that the scientist used to see exactly how they conducted their experiments.

Another way that I became familiar with past research efforts was by talking to Reynolds' scientists who were there before I started and who conducted those experiments. I solicited their opinions about their research to get insight into their experiments.

Q. How far back in time do the internal research reports, memoranda and laboratory notebooks go?

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A. They go back to the time the R&D library was first formed, which was in the early 1950s.

Q. At any point during your tenure, were you responsible for advertising or marketing for Reynolds?

A. No.

Q. At any point during your tenure, were you responsible for public relations or external relations for Reynolds?

A. No.

C. PROFESSIONAL PUBLICATIONS AND PRESENTATIONS

Q. Dr. Townsend, have you published any scientific articles in the peer-reviewed literature while you've been employed at Reynolds?

A. Yes.

Q. Have you also lectured and presented papers on cigarette research and design during your employment with Reynolds?

A. Yes, I have.

Q. Do you hold any patents in the area of cigarette design?

A. Yes.

Q. Are there other scientists at Reynolds who also hold patents in the area of cigarette design?

A. Yes, there are quite a few.

Q. How many total patents have Reynolds' scientists obtained since the company was formed?

A. We have obtained approximately 700 patents.

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D. PROFESSIONAL AFFILIATIONS

Q. Are you a member of any professional organizations in your field?

A. Yes, I am a member of several organizations. I am a member of the American Chemical Society, the premier organization for chemists in the United States. I am also a member of The Combustion Institute, in which I became involved a number of years ago because of the importance that the combustion process has to my job. In addition, I have participated in the Cooperation Center for Scientific Research Relative to Tobacco ("CORESTA") organization and various Tobacco Science Research Conferences ("TSRC").

Q. What is CORESTA?

A. CORESTA is an association that was founded in the 1950s in France. Its purpose is to promote international cooperation in scientific research on tobacco. Membership is open to organizations having research and development activities related to tobacco, including agriculture, cigarette design and manufacturing, suppliers, and even research institutes. CORESTA organizes yearly conferences and periodic meetings in which scientific papers are presented.

Q. Do you know how many members CORESTA had at the time you retired?

A. Yes, there were just under 200 full member companies, the majority of which are based in Europe.

Q. Do you hold any positions with CORESTA?

A. Not currently, but I have had several positions in that organization. In October 2004, I stepped down as vice-president of the board of CORESTA after having served in that capacity for about four years. Between 1990 and 2000, I was a member of CORESTA's Scientific Commission, which was responsible for directing all of CORESTA's scientific work.

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Q. What is TSRC?

A. The TSRC was originally called the Tobacco Chemists Research Conference and is an annual conference where presentations are given on research related to tobacco and cigarettes. The conferences have occurred annually since the 1940s.

Q. Are CORESTA and TSRC limited to scientists from cigarette manufacturers?

A. No, they are not. There are people who participate in CORESTA and TSRC who are not with the cigarette companies or their suppliers. For example, Dr. Dietrich Hoffmann, who was with the American Health Foundation, and various of his colleagues have attended TSRC meetings and made presentations on their research efforts on cigarettes for many years. In addition, some scientists from the U.S. Department of Agriculture have participated in TSRC, including Dr. T.C. Tso who served as the chairman of one of the conferences.

E. GOVERNMENT TASK FORCES

Q. Have you also served on governmental task forces related to cigarette design?

A. Yes.

Q. Please describe the task forces on which you have served.

A. I was a member of a group called the Technical Study Group, which was created by Congress in the 1980s. Its Congressionally-mandated objective was to determine whether it was possible to design a cigarette that is less likely to start a fire if it is accidentally dropped on upholstered furniture. I was a member of that technical study group until it finished its work in 1987.

In 1990, Congress formed another task force called the Technical Advisory Group, that existed until 1993. I was a member of that group as well. The purpose of the Technical Advisory Group was to try to develop a standardized test method to compare cigarettes for the likelihood of starting fires if they are accidentally dropped on upholstered furniture.

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F. CONFERENCES ON CIGARETTE DESIGN AND MODIFICATION

Q. Have you been an invited speaker at government-sponsored conferences on cigarette design and modification?

A. Yes.

Q. Please describe the government-sponsored conferences in which you were an invited speaker.

A. In 1994, I was invited to be an expert speaker at a National Cancer Institute-sponsored conference examining the Federal Trade Commission ("FTC") cigarette smoking method. There were fourteen invited experts who made presentations, and were asked to provide input on whether or not the FTC's smoking method needed to be changed. Dr. Donald deBethizy, a toxicologist at Reynolds, also attended and spoke at the conference. Dr. deBethizy and I were the only speakers from the cigarette manufacturers invited to participate. In 1996, a report of the conference was issued by the National Cancer Institute as Monograph No. 7, entitled "The FTC Cigarette Test Method for Determining Tar, Nicotine, and Carbon Monoxide Yields of U.S. Cigarettes." [JE-045979]

In 1996, Dr. deBethizy and I were invited by the Canadian government to participate in a conference with other scientists to discuss approaches to cigarette modification intended to reduce the risks of smoking. We were the only scientists from the United States cigarette manufacturers invited to participate. The proceedings from this conference were published in a report entitled "Report of Canada's Expert Committee on Cigarette Modifications," designated as exhibit JD-000676.

Q. Do you know who Dr. William Farone is?

A. Yes.

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Q. Do you recall if Dr. William Farone participated in these government-sponsored conferences on cigarette design?

A. Dr. Farone was not a participant.

G. OPINIONS TO BE OFFERED

Q. Dr. Townsend, did I ask you to come here to provide the Court with your expert opinions and fact testimony about the claims and allegations made by some of Plaintiff's experts in the area of cigarette design?

A. Yes.

Q. Have you reviewed the trial testimony of some of Plaintiff's experts in this case at my request?

A. Yes.

Q. What exactly did you review?

A. I reviewed portions of the written direct examinations and live trial testimony of Dr. Jeffrey Harris, Dr. William Farone, Dr. Jack Henningfield and Dr. David Burns. In addition, I reviewed the Reynolds documents in my area of expertise that were discussed in those examinations or otherwise submitted with their testimony.

Q. Did I also ask you to come here to provide the Court with your expert opinions and fact testimony regarding the specific efforts of Reynolds to reduce the health risks of cigarette smoking?

A. Yes.

Q. Did I also ask you to come here to provide the Court with your expert opinions and fact testimony about whether there is a safer, feasible alternative design that is superior to the cigarettes that Reynolds and its competitors have manufactured and sold?

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A. Yes.

Q. In terms of the structure of your testimony, Dr. Townsend, I first want to focus on the efforts that have been made to try to reduce the inherent health risks of smoking, and then turn to the various allegations that have been made in this case relevant to your areas of expertise and knowledge, okay?

A. Yes, I understand.

III. RISK REDUCTION AND CIGARETTE DESIGN

Q. Doctor, can you identify a single reasonable approach to making a potentially less hazardous cigarette that Reynolds failed to pursue?

A. No.

Q. Can you identify a single, commercially feasible cigarette design that was potentially safer than Reynolds' existing products that Reynolds developed but did not market?

A. No.

Q. In addition to the cigarette manufacturing defendants in this case, have there been, and are there today, other cigarette companies in the United States?

A. Yes. Particularly since the MSA, there has been a significant increase in the number of cigarette companies in the United States.

Q. Are there other cigarette companies throughout the world?

A. Yes.

Q. Can you identify a cigarette design sold anywhere in the world that is safer than the cigarettes sold in this country by one or more of the defendant cigarette manufacturers?

A. No.

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Q. How do you know that?

A. Because, as part of our work in the R&D Department, we keep up with design developments by other companies, including those in Europe and Japan, for example.

Q. Why do you do that?

A. If another company has discovered something that's an important design factor, we want to understand it, know how it works, and try to get ahead of the curve.

Q. Does Reynolds ever analyze the cigarettes that are made or manufactured by another company?

A. We do that all the time.

Q. What type of analysis do you do?

A. We routinely pick up in the marketplace new products or some of our key competitors' products. In the laboratory, we examine their physical characteristics, such as length, diameter, and weight. We'll dissect the products and look at the tobacco blend to try to determine if there are any differences. We also will investigate the non-tobacco materials they use, like the filter and cigarette paper.

We'll always smoke the cigarette under FTC conditions to determine its tar, nicotine and carbon monoxide yields. Frequently, we'll smoke them under special analytical methodologies to try to understand the more detailed smoke chemistry. We go in and try to look at some of the constituents that are markers so that we understand the performance of our competitors' cigarettes.

Also, we have expert smoker panels within Reynolds who will smoke competitive products to see how they taste compared to ours. Because our goal is to beat the competition, we have to stay on top of what they are doing in the marketplace.

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A. THE MODERN CIGARETTE

Q. Dr. Townsend, cigarettes from the 1950s and today look pretty much the same; are they the same?

A. No. In fact, the cigarettes of today are really quite different from those of the 1950s.

Q. Before I ask you to describe some of those differences, it might be helpful to briefly review the construction of the modern cigarette. Have you prepared a chart that will assist you in describing the construction of the modern cigarette?

A. Yes.

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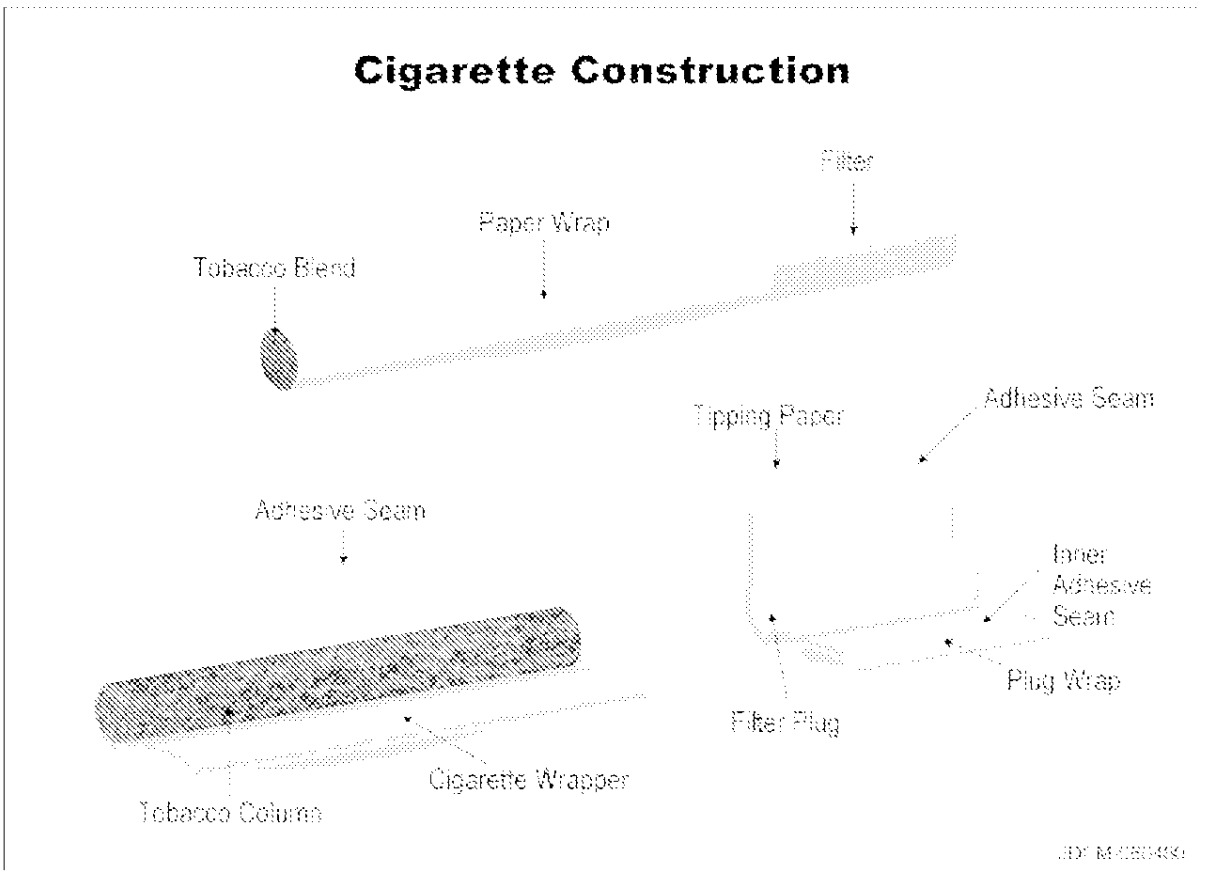

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Q. Please describe what you have depicted on your chart.

A. This chart is a cut-away representing the two main sections of the modern cigarette: the tobacco rod, or tobacco column, and the filter section.

The tobacco that's used in modern cigarettes is a blend of burley, flue-cured, and Turkish, as well as some processed tobaccos like expanded or reconstituted tobaccos. The tobacco blend is wrapped in a paper of very tightly controlled properties, in terms of its permeability and basis weight. The tobacco and cigarette paper are formed into a rod and held together with a seam adhesive.

As to the filter, it is typically made of cellulose acetate, which is a processed form of cellulose from trees. The cellulose acetate is spun into fibers by suppliers and we take those fibers, bundle them, and form them into a cylinder shape that is wrapped with paper called plug wrap. The function of the plug wrap is simply to hold the bundle of fibers together. Plug wrap paper is typically very porous and looks a lot like the paper used for tea bags. In fact, some of our plug wrap suppliers have also made tea bag paper.

Finally, the tobacco rod is attached to the filter by what we call the tipping paper. Tipping paper often is cork colored, but is sometimes white. The sole function of the tipping paper is to attach the filter subassembly to the tobacco rod. It covers the entire length of the filter and overlaps the tobacco rod by 3 or 4 millimeters.

Q. With that background, please provide the Court with some examples of how today's cigarettes differ from those sold in the 1950s.

A. Up until the early 1950s, virtually all of the commercial cigarettes were unfiltered and approximately 70 millimeters in length. Beginning in the mid-1950s and continuing for decades thereafter, Reynolds and the other cigarette manufacturers, implemented various innovations into cigarettes. Dimensionally, the modern cigarette tends to have a smaller

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circumference. There are significant differences in the composition of the tobacco blends that are used, including the use of a number of processed tobaccos that were developed since the 1950s. Also, cigarette paper is much more porous today than in the 1950s, and it's much more tightly controlled in terms of its manufacture and physical properties. Today's filters are engineered to provide high efficiency filtration, much higher than compared to a cigarette in the 1950s. Additionally, the whole technology of filter ventilation has been developed since the 1950s. These are just some of the technological changes that have been made in cigarettes over the past 50 years.

Q. How are you able to compare today's cigarettes to those in the 1950s?

A. Through company records, we can go back and look at specifications of cigarettes. We can even go back in many cases to freezers where we have cigarettes from the 1960s and in some cases the 1950s in storage to make direct comparisons.

Q. Did those cigarette design changes come about by accident?

A. No. They came about through research and development, for example, through work that was done at Reynolds and our competitors' companies.

B. OBSTACLES TO THE DEVELOPMENT OF REDUCED RISK CIGARETTES

Q. To be clear, Dr. Townsend, has Reynolds tried to reduce the health risks of smoking?

A. Yes, absolutely.

Q. For how long has Reynolds made that effort?

A. Since the early 1950s.

Q. Is it easy to develop a reduced risk cigarette?

A. No, it is very difficult.

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Q. What steps does a cigarette designer, such as yourself, go through in the process of developing and evaluating new cigarette designs?

A. There are really three broad steps. The first step is to determine a clear and specific design objective – exactly what is it that is hoped to be accomplished.

The second step is to determine technical feasibility. The product developer has to go into the laboratory and figure out how to meet the design objective.

The third step in cigarette design is evaluating commercial feasibility. Commercial feasibility encompasses several things. It includes ensuring that the new product can be made within specifications reproducibly in a manufacturing environment, that the new product is consumer acceptable and that smokers will, in fact, buy it, and that the new product meets all regulatory and product stewardship constraints.

1. IDENTIFYING SPECIFIC DESIGN OBJECTIVES

Q. Focusing on the first step, what are some examples of specific design objectives?

A. There are quite a few, as you can imagine. One possible design objective may be to reduce the tar yield, but keep the nicotine level at some particular yield. In other words, you may want to change the amount of tar and nicotine independently of each other. Another objective may be to specifically reduce particular smoke constituents, such as the polycyclic aromatic hydrocarbons. Or, another design objective might be to significantly simplify smoke chemistry and reduce biological activity.

Q. How do you identify specific design objectives?

A. From the scientific literature, particularly the literature on smoking and health. That literature has generated hypotheses about how cigarette smoke, and the compounds in the

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smoke, may be responsible for the significant health risks. Those hypotheses explicitly or implicitly suggest cigarette design modifications that might reduce the risks of smoking.

Q. Has the explicit or implicit guidance to Reynolds and other cigarette manufacturers from the scientific and public health literature been consistent?

A. Yes and no.

Q. In what respects has the guidance to Reynolds and other cigarette manufacturers from the scientific and public health literature been consistent?

A. Beginning in the 1950s and continuing until at least very recently, there was clear guidance and a general consensus that reducing all smoke constituents would reduce risk. That consensus was supported in large part by the results of many epidemiological studies, as well as the well-known toxicological principle of "less ought to be better." In recent years, some members of the public health community have questioned the merits of that recommendation.

Q. In what respects has the guidance to Reynolds and other cigarette manufacturers from the scientific and public health literature been inconsistent?

A. Different scientists have different theories about what is occurring, either in the chemistry of the smoke, or when animals or humans are exposed to smoke. As a consequence there are different explicit or implicit suggestions about what specific compounds in smoke are most important to reduce. For example, one scientist may believe that polycyclic aromatic hydrocarbons are extremely important. Another scientist may believe that nitrosamines are extremely important. And there have even been instances of scientists completely reversing their recommendation about what should be done to potentially reduce risk. So there have been very different hypotheses, and sometimes they change, which I should say is not unexpected in science.

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Q. You mentioned some recommendations that have been reversed. Can you provide an example?

A. Yes. Early on, there was one argument that benzo[a]pyrene, a polycyclic aromatic hydrocarbon, was probably involved in the development of lung cancer. It was a reasonable hypothesis because benzo[a]pyrene had already been shown to produce tumors in mouse skin painting studies on the backs of mice, and benzo[a]pyrene was thought to be present in cigarette smoke because it is a combustion by-product. Most combustion processes, whether it's the burning cigarette or burning leaves, can generate some benzo[a]pyrene.

In the 1960s, Dr. Dietrich Hoffmann, who as I testified earlier was with the American Health Foundation, evaluated that theory and advocated adding certain additives to tobacco, like nitrates, to reduce benzo[a]pyrene. And, to a degree, adding nitrates does have an effect on benzo[a]pyrene, as has been shown experimentally. However, adding nitrate will increase another class of compounds called tobacco-specific nitrosamines, which are also thought by some scientists to be involved in the production of cancer. Subsequent to that finding, Dr. Hoffmann reversed his position and recommended against adding nitrates to tobacco.

Q. What about nicotine; has the public health community and the public health literature given suggestions as to what should be done to the amount of nicotine in a typical cigarette as a possible way to reduce risk?

A. There have been a number of suggestions that go in different directions, actually. Some scientists have advocated making a very low-nicotine cigarette, and even a no-nicotine cigarette, as a way to make a safer cigarette. Other scientists have recommended that the current level of nicotine should be maintained, or even increased, while tar is reduced as much as possible. The underlying hypothesis is that the components in tar are responsible for causing cancer, not nicotine. Therefore, a safer cigarette might be developed by maintaining

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some moderate level of nicotine, while reducing the tar as much as possible. So there have been two very different schools of thought.

Q. Who are some of the scientists who have recommended the higher nicotine, lower tar approach?

A. Several scientists have recommended that approach. Sir Richard Doll from England is one. Professor Michael Russell, who is with the Institute of Psychiatry at the University of London, is another. Dr. Gio Gori, who was a former director with the National Cancer Institute and the Tobacco Working Group in the 1970s, and various Surgeons General, all have recommended a higher nicotine, lower tar cigarette.

Q. And, who are some of the scientists who have advocated the opposite, that is a very low, or no, nicotine cigarette?

A. Two notable people are Drs. Jack Henningfield and Neal Benowitz.

Q. Are you aware that Drs. Henningfield and Benowitz testified in this case on behalf of the Government?

A. Yes.

Q. Generally, how has the lack of consistent and uniform suggestions and theories regarding particular smoke constituents affected cigarette design efforts?

A. It's frustrating, but it really has not had a dramatic effect because we at Reynolds consider and evaluate all serious and reasonable ideas about how to potentially reduce risk. And we have gone, and continue to go, in various directions to try to modify cigarettes and reduce risk. We take these different and sometimes conflicting hypotheses, and we assume that they're correct, and we go in the lab and try to develop technically feasible approaches to respond to the theories. If we're successful, and the concept shows promise, we then try to see if we can make the approach commercially feasible.

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2. CONSUMER ACCEPTANCE

Q. How does consumer acceptance rank as a factor in cigarette design?

A. Making sure that you have a consumer acceptable product is essential. If you have gone through the whole process of meeting design objectives and technical objectives but consumers won't buy the product, you really have done nothing useful in that modification or design change.

Q. Is consumer acceptance also an important consideration with potentially less hazardous cigarettes?

A. Yes.

Q. Have other scientists recognized the importance of consumer acceptability to the design of potentially less hazardous cigarettes?

A. Yes. For example, Dr. Wynder recognized this fact.

Q. Let me show you JD-000659 and ask you to identify it.

A. This book reports on the proceedings from the Banbury Conference on Less Hazardous Cigarettes held in 1979.

Q. What was the Banbury conference?

A. It was a conference held in New York in 1979 in which various scientists from the government, public health community and medical universities met to discuss the possibilities and issues in designing potentially safer cigarettes. Some of the notable conference participants included Ernst Wynder and Dietrich Hoffmann of the American Health Foundation, Gio Gori of the National Cancer Institute, T.C. Tso of the U.S. Department of Agriculture, and Michael Russell from the Institute of Psychiatry.

Q. Turn to page 6 of JD-000659, what does Dr. Wynder state with respect to the importance of consumer acceptability?

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A. "Research on the less harmful cigarette should therefore be directed toward developing a cigarette containing the lowest possible amount of harmful elements for all tobacco-related diseases, but one that has sufficient acceptability for the largest segment of smokers."

Q. Can consumer acceptance be achieved simply by adding nicotine and flavors to a cigarette?

A. No, it cannot. Achieving consumer acceptability, particularly with innovative designs, is difficult and requires balancing many factors. People smoke cigarettes for more reasons than just to get nicotine. Why people smoke is a very complex issue. And consumer acceptability is not simply satisfied with flavors or nicotine.

Q. Can you provide some examples of factors that affect consumer acceptability of a cigarette?

A. Yes. Taste and aroma are certainly among the most important factors. In addition, how hard it is to draw on the cigarette is important, as are the number of puffs and even the ash characteristics.

Q. Can you provide some examples of cigarettes that met some technical objective, but were not consumer acceptable in the marketplace?

A. Yes, there are actually a number of cigarettes that we've developed that have not cleared this hurdle. One early example was the charcoal filtered cigarette. Most of the cigarette manufacturers introduced charcoal filtered cigarettes beginning in the 1960s. Reynolds' brand was called Tempo, a cigarette that we sold from the mid-1960s to the late 1970s. Although Tempo and the other charcoal filtered cigarettes achieved reductions in certain gas phase compounds, they had a very different taste. Despite a fair amount of initial

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trial, those cigarettes have not been consumer acceptable in the United States. There are still a few charcoal filtered cigarettes on the market today, but their sales are poor.

Another example are the lowest of the ultra-low tar cigarettes, those that yield 1 milligram or less of tar. Cigarettes in that category, what I call the "lowest," entered the market in the mid-1970s. Although cigarettes in the lowest category are still commercially available, for the most part, they have very low consumer acceptance. Because of their extraordinary low yields, smokers complain about the lack of taste and sensory characteristics of the smoke, in addition to their draw characteristics.

An example by one of Reynolds' competitors, Philip Morris, was a cigarette called Next, which used a specially-processed tobacco that yielded very low nicotine, but regular levels of tar. Although there was some initial trial, smokers did not accept Next and it failed. Philip Morris actually incorporated the processed tobaccos in other brand styles besides Next, but they all failed.

3. HEALTH REPRESENTATIONS AND CONSUMER ACCEPTANCE

Q. Wouldn't consumers be more likely to accept cigarettes with unusual taste or sensory characteristics, such as charcoal filtered cigarettes, if cigarette manufacturers told them they were potentially safer?

A. Yes, presumably, but it may not have as big an effect on consumer acceptance as you might think and there are significant limitations on what manufacturers can say.

Q. I realize that you are not a lawyer but what is your understanding, as somebody who has worked in cigarette design for 27 years, of the limitations on what manufacturers can tell smokers about potentially reduced risk products?

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A. The Federal Trade Commission requires that manufacturers substantiate even implicit health claims, other than claims that a cigarette yields less tar and nicotine under the FTC's test. Additionally, express health claims might give rise to Food and Drug Administration regulation which, if it occurred, likely would result in banning the product.

Q. Dr. Jeffrey Harris, an expert economist for the Government in this case, testified at trial that the FTC has had "toothless involvement" in these issues. [Trial testimony, 2547:24-2548:6]. Is that consistent with your understanding and experience?

A. No.

When Reynolds marketed its tobacco-heating cigarette, Premier, we said it was "cleaner" because it reduced many controversial compounds in cigarette smoke, which it did. Before Premier was withdrawn from the market, the FTC had started an investigation and the FDA was considering whether to regulate it.

Moreover, the FTC also took action against Brown & Williamson over its Barclay cigarette in response to complaints from Reynolds and Philip Morris.

Finally, if a manufacturer is going to make claims about tar and nicotine yields, those claims must be substantiated pursuant to the FTC's test.

Q. Is substantiation of health claims for new cigarette designs difficult?

A. It's extremely difficult for at least two reasons.

First, epidemiological evidence will not be available until the new product has been on the market and used by consumers for a significant time.

Second, with the possible exception of the FTC's test for tar and nicotine yields, the government has defined no objective criteria or standards by which to demonstrate whether one cigarette is safer than another. Nor is there a scientific consensus on what objective criteria or standards can be used. There is not a scientific consensus on what specific

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constituents in the complex mixture of smoke are responsible for the health risks of smoking, much less a consensus on how much those specific constituents need to be reduced in order to reduce health risks.

Q. In light of this vacuum, what has Reynolds done?

A. After our experience with Premier, Reynolds developed a battery of assays and biological tests that we believe makes sense and can indicate whether there is probable reduction in risk. Is that generally accepted in the scientific community? Not yet. But what we're out there doing is publishing and presenting on our approaches, encouraging debate, and encouraging people to come up with other ideas so that we can get to a consensus.

Second, we've done a number of things with outside scientists, other companies and other organizations. For example, we're working with scientists today trying to develop an animal lung tumor model. We're funding some research at one university looking at cancer models in rodents, trying to see if we can develop another assay or test that will be faster and cheaper than the mouse skin painting study and will hopefully give us better and more complete information. We're looking at a number of things.

Third, we've shared our approaches and opinions with various organizations and governmental entities around the world. Our scientists have made presentations and participated in meetings with such entities as the World Health Organization and the Canadian government; and in the United States, we've met with the Centers for Disease Control, the Institute of Medicine, the Food and Drug Administration, the Federal Trade Commission, and various state agencies.

Q. You testified earlier that telling smokers that a cigarette that potentially posed less risk may not have as big an effect on consumer acceptance as one might think. What did you mean?

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A. Using the battery of tests and assays that Reynolds thinks can indicate whether there is probable reduction in risk with a new cigarette design, Reynolds has told smokers that its new tobacco-heating cigarette, Eclipse, "may present less risk of cancer, chronic bronchitis and possibly emphysema." The product admittedly is significantly different in terms of its taste and performance than conventional tobacco-burning cigarettes, but the claims made for Eclipse, which we've made since 2000, have not made Eclipse a commercial success yet.

Q. Has the government taken steps in response to the claims Reynolds has made for Eclipse?

A. Yes, as with Premier, there were complaints and petitions to the FTC and FDA requesting regulation of Eclipse. JD-041961, JD-065307 and JD-062455 are examples.

In April 2000, after we started making claims that Eclipse may present less risk of certain smoking-related diseases, Donna Shalala, then Secretary of the Department of Health and Human Services, issued a press release critical of Reynolds' claims.

More recently, several state attorneys' general have instituted investigative actions claiming that Eclipse advertisements may be false and deceptive.

Q. We'll discuss Eclipse and other design innovations in more detail later, but please tell the Court now your general assessment of the relative strength of the scientific evidence for the claims Reynolds makes for Eclipse compared to the scientific evidence for potential health claims for design modifications for conventional, tobacco-burning cigarettes?

A. The scientific evidence supporting the claims Reynolds makes for Eclipse is much stronger than any scientific evidence I have seen for any conventional, tobacco-burning cigarette.

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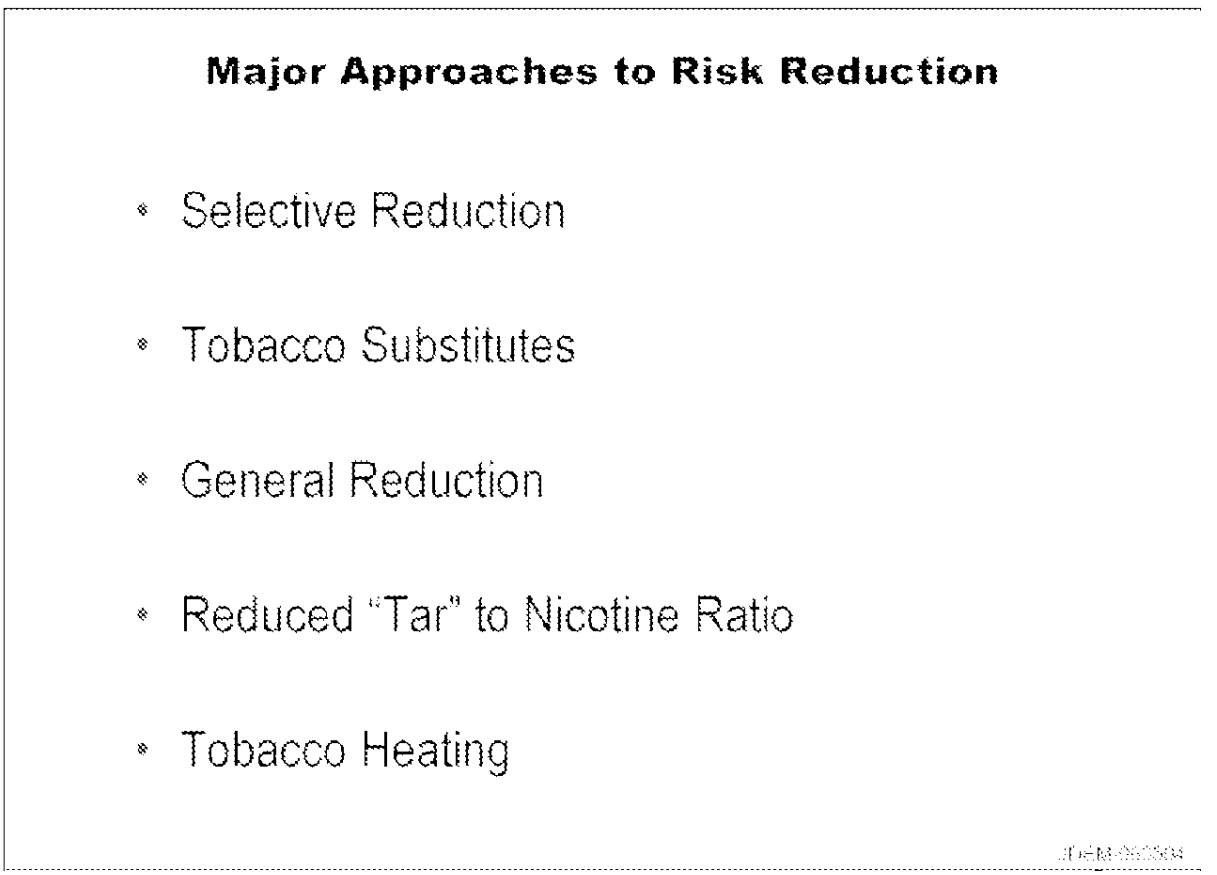
C. MAJOR DESIGN APPROACHES TO CIGARETTE RISK REDUCTION

Q. Have you prepared a chart that categorizes the different ways in which cigarette manufacturers, including Reynolds, have approached risk reduction in cigarettes over the past 50 years?

A. Yes.

Major Approaches to Risk Reduction

- Selective Reduction
- Tobacco Substitutes
- General Reduction
- Reduced "Tar" to Nicotine Ratio
- Tobacco Heating



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Q. Please explain briefly the five major approaches.

A. A lot of research has been conducted over 50 years, but I generally consider that research to have fallen into five basic categories: selective reduction – attempting to remove or reduce specific constituents of smoke; tobacco substitutes – replacing tobacco with another material that generates simpler smoke chemistry; general reduction – reducing all smoke constituents across the board; altering the tar-to-nicotine ratio – changing the amount of nicotine yielded per unit tar; and tobacco heating – dramatically simplifying smoke chemistry by heating, rather than burning, tobacco.

Q. Are you prepared to testify regarding each of those approaches?

A. Yes.

IV. RISK REDUCTION THROUGH SELECTIVE REDUCTION

Q. Dr. Townsend, I would now like to take the Court though some of the major efforts to reduce the risks associated with cigarettes, starting with what you called "selective reduction." Generally, what do you mean by selective reduction?

A. Selective reduction is one of our approaches to reducing risk. It's based on the idea that there is one compound or one group of compounds that have similar properties that are responsible for the increased disease risk. If one went in and removed that compound or greatly reduced it, similar to going into this complex mixture with a scalpel and carving it out, then you may reduce the risk. So the idea is to go in and remove or reduce the levels of those compounds in smoke, keeping everything else the same, just selectively targeting those particular compounds. And we call that approach selective reduction.

A. TECHNICAL DIFFICULTIES WITH SELECTIVE REDUCTION

Q. Is selective reduction easy to do from a technical standpoint?

A. No.

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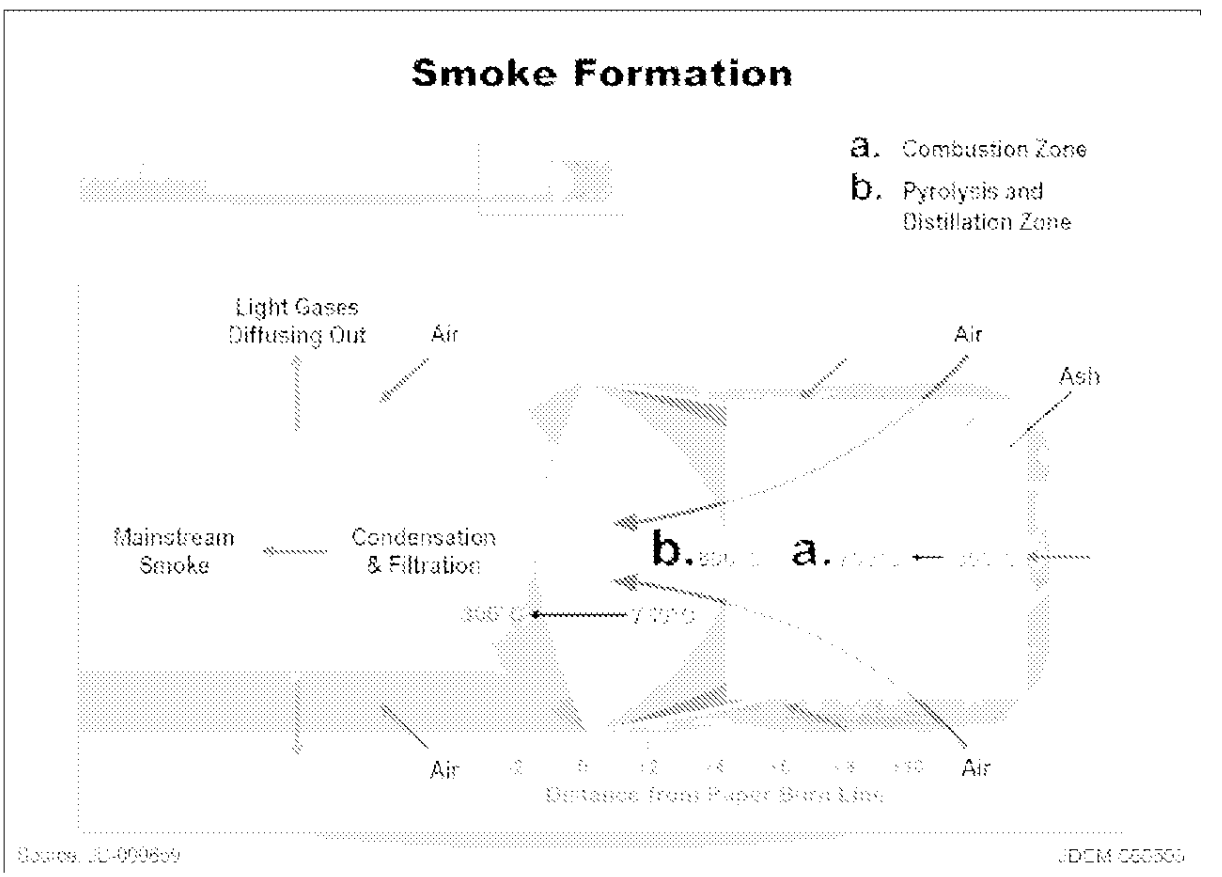
Q. Why is it difficult technically?

A. Because the smoke generated by a burning cigarette is dynamic and complex.

1. THE BURNING CIGARETTE

Q. Have you prepared a chart that will assist you in explaining what happens when a cigarette is lit and burns?

A. Yes.



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Q. Using your chart, please explain what happens when a cigarette is lit and burns.

A. What I have depicted is a burning cigarette with the tobacco rod to the left and the lit end, or fire cone, to the right. There's a sheathe of ash on the lit end which provides a lot of insulation to the burning ember. The zero point is at the leading edge of the cigarette paper. When the cigarette is puffed, air comes into the cigarette near the base of the fire cone. Very little air goes through the ember because that's such a high-temperature region and it is very difficult for air to get through. So, most of the air comes in right in front of the leading edge of the cigarette paper where the pressure drop is lowest. The air enters just past the burning ember and temperatures in the peripheral region can reach 1,200 degrees Celsius, which is over 2,000 degrees Fahrenheit. After the air enters, it is heated, and the oxygen in it is burned. The oxygen-deficient hot gas then travels down into the tobacco column and heats the tobacco to the point where it starts to decompose. Once the tobacco starts to decompose, it generates vapor phase organic materials at a very high concentration. The decomposition products from the tobacco are swept down the tobacco column and cooled. As those gases cool, they condense and start to form little droplets suspended in a gas phase medium. That is what we call smoke. So, cigarette smoke is composed of two phases: a droplet, or particle, phase and a gas phase.

The smoke continues down the tobacco rod and there are quite a lot of changes that occur before the smoke exits the mouth end of the cigarette. Some low molecular weight gases can escape out of the cigarette rod by diffusing through the cigarette paper. Air can be drawn in through the cigarette paper which can dilute the smoke. Some of the material that's in the smoke can be directly condensed onto the unburned tobacco still in the cigarette rod. Some of the particles are actually removed by the tobacco. Then, after the smoke travels the full length of tobacco rod and enters the filter, of course, there are more processes that occur

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which affect the smoke that ultimately exits the mouth end of the cigarette. But this is just a brief description of some of the processes that occur in the very front end of the cigarette during a puff.

Q. Scientifically, how is cigarette smoke classified?

A. Cigarette smoke is classified as an aerosol. An aerosol is composed of particles suspended in a gas phase medium. If one drives down a dusty road and there is a cloud of dust, that's an aerosol because you have solid particles suspended in a gas phase medium. Another example is early morning fog, which is considered a condensation aerosol. In the case of cigarette smoke, the particles are primarily liquid in nature. They are liquid particles that are suspended in a gas phase medium. These particles are so small that you can't really see them directly. Although you can't see the individual particles per se, you do see a cloud of smoke because light is actually scattered in different ways by these particles.

2. CIGARETTE SMOKE IS COMPLEX

Q. You said that cigarette smoke is complex. Why did you say that?

A. The particulate phase is composed of thousands of compounds, most of them at very, very low levels. The gas phase that surrounds these particles is also a very complex mixture of compounds. In fact, if you look at what's known scientifically today about cigarette smoke, about 5,000 compounds have been identified to date in cigarette smoke.

Q. Have you prepared an exhibit that will help explain the composition of cigarette smoke?

A. Yes. I have a chart that was taken from a figure in the 1989 Surgeon General's Report.

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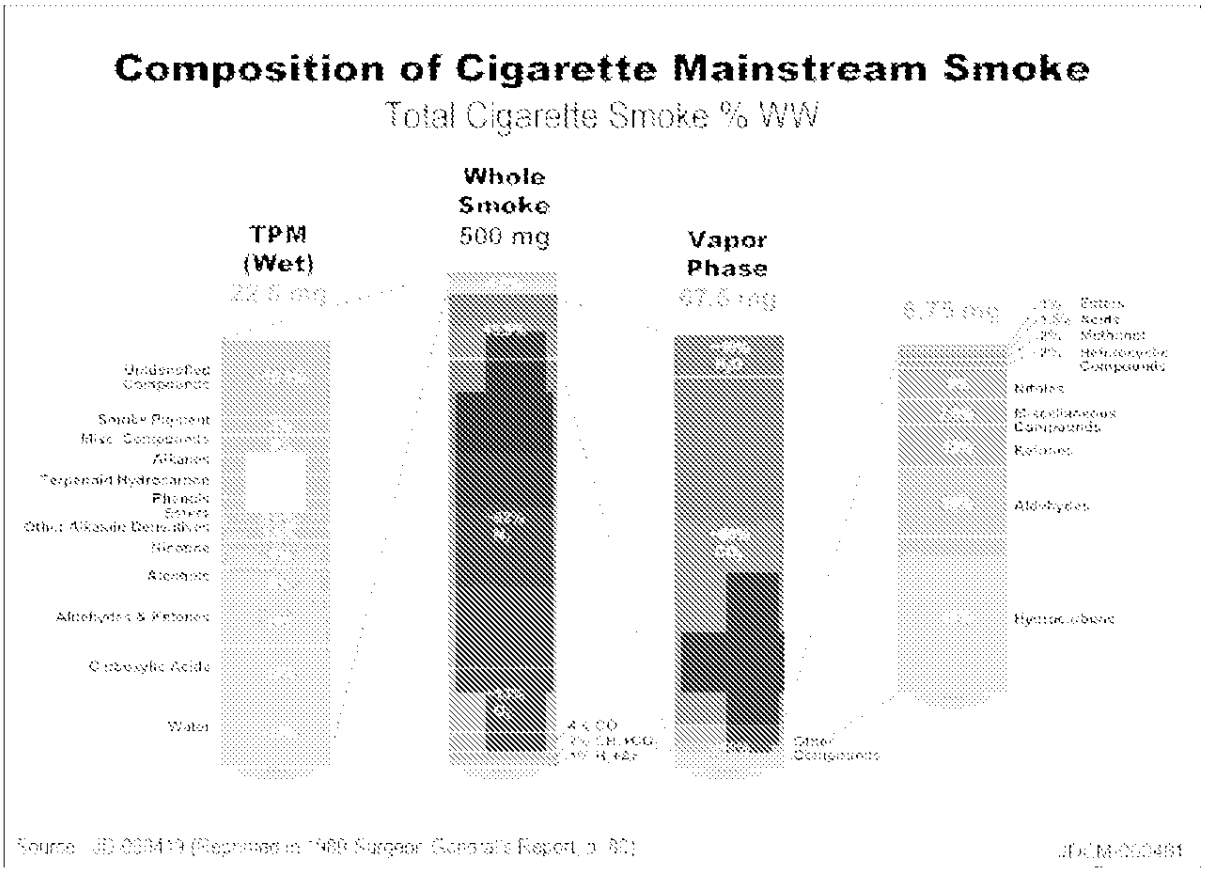

Q. What does this chart show about the composition of cigarette smoke?

A. The chart itself is complicated and in my opinion is a reflection of the complex nature of smoke. Let me start out the explanation in a general way. The cigarette smoke as it comes out the back end or the mouth end of the cigarette is called whole smoke. If one asked the question, "What's the gross composition of that smoke?", the answer is represented on the chart by the second column from the left and would be as follows: Approximately 62 percent of the weight of that whole smoke is nitrogen, about 13 percent is oxygen and 13 to 14 percent of the weight of that smoke is what we call vapor phase compounds or gas phase compounds. Lastly, about 4.5 or 5 percent of the weight of that smoke is what we call

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total particulate material, or "TPM." This includes the non-volatile/non-gas phase compounds.

If you break out the TPM, which is the column all the way on the left of my chart, a chemical analysis of that has been done to determine its composition. Approximately 16 percent of TPM is water, about 13 percent is a variety of organic compounds called carboxylic acids, another 11 percent is composed of aldehydes and ketones which are different types of organic compounds. Eight percent are alcohols and about 6 percent of that is nicotine. In addition, there are other alkaloids and then a large percentage of the particulate matter, about 17 percent, that is still yet unidentified.

Focusing on the vapor phase portion, which is 13.5 percent of whole smoke and is represented by the third column from the left in my chart, the majority is carbon monoxide produced from the combustion of tobacco. Water and a very complex mixture of other compounds contribute to the other 20 percent.

In that 10% category labeled "Other compounds", I've broken that out as the column all the way on the right of my chart. We've identified a number of those compounds, including hydrocarbons, aldehydes, ketones, nitriles, esters, methanol, and heterocyclic compounds. The bottom line is that the vapor phase is a very complex mixture as well.

Q. What's the source of this information from your chart?

A. The chart in the 1989 Surgeon General's Report comes from a publication by Drs. Mike Dube and Charles Green. Their publication is designated as JD-060419.

Q. Do you know those gentlemen?

A. Yes, I do. They're both scientists at Reynolds. Dr. Green is now retired, but Dr. Dube is still with Reynolds.

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Q. In describing your chart, you said that about 17 percent of the TPM component of smoke was unidentified. Why is that?

A. Because smoke is a very complex mixture and the constituents that we are measuring are present at exceedingly low levels. Our present analytical capabilities can only measure down to certain levels, in the nanogram and picogram range, generally. Although we've found some constituents as low as the femtogram range. As analytical techniques improve, I'm certain we'll be able to identify additional constituents.

Q. How small of a unit of measurement are nanograms, picograms and femtograms?

A. A nanogram equals one-billionth of a gram. As perspective, a package of sweetener, like Equal, contains about one gram. So, a nanogram would be about one-billionth of a pack of Equal.

A picogram equals one-trillionth of a gram. And below a picogram is a femtogram, which equals one-quadrillionth of a gram.

Q. Dr. Townsend, how have we come to know so much about smoke chemistry?

A. Because scientists at Reynolds, other cigarette companies, and outside entities have spent decades collecting and analyzing cigarette smoke.

Q. Has modern technology aided in the understanding of smoke chemistry?

A. There is no question that since the early 1950s, chemistry, and analytical chemistry particularly, has advanced tremendously. And because the new techniques have been developed for the laboratory, we've been able to identify more and more compounds in smoke at lower and lower levels.

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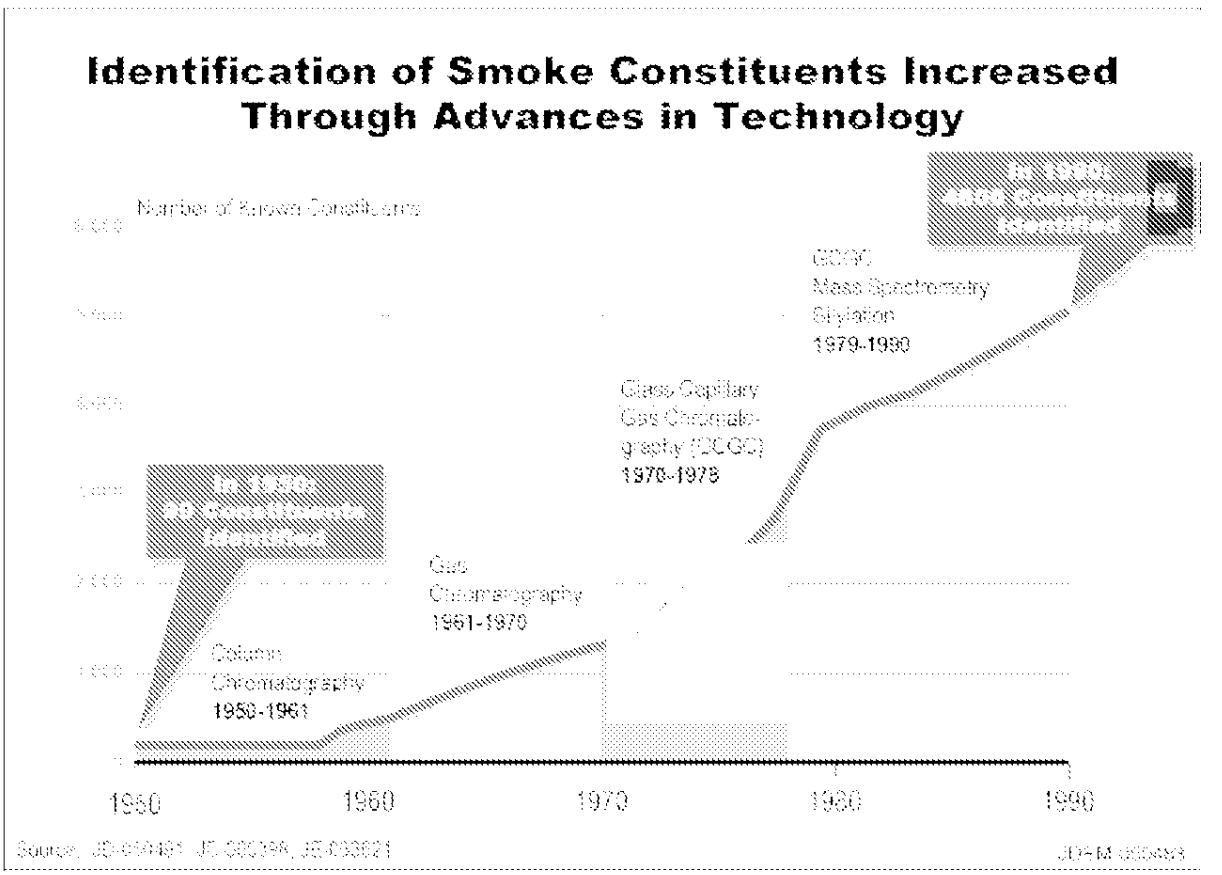
Q. Do you have an exhibit showing how modern technology has contributed to our understanding of smoke chemistry?

A. Yes, I do.



Q. Will you please explain your chart to the Court?

A. Yes. What I have is a graph of the number of reported constituents that we have identified in cigarette smoke as a function of time beginning back in the early 1950s and carrying on to the 1990s. I've already said that we know of about 5,000 constituents in cigarette smoke and that there certainly are more. This chart shows why I think that there are more: the number of constituents that we know of depends directly on the sophistication of our analytical chemistry techniques.

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Back in the early 1950s, analytical chemistry was really fairly crude. It was very difficult to measure and identify compounds particularly in a complex mixture so at that time we knew of only about 90-100 compounds that were present in smoke. As we developed improved analytical techniques, particularly gas chromatography which was developed during this time period, there was a very sharp rise in the number of known compounds in smoke because now we had the tools to measure and to identify those compounds.

Another very important technique that was developed was glass capillary/gas chromatography. It was a major improvement in gas chromatography, and its development caused another steep rise in the number of known compounds. Even later, gas chromatography connected with mass spectrometry, and again further increased our knowledge. So by 1990, there were close to 5,000 identified compounds. We actually did a lot of pioneering work in the area of gas chromatography/mass spectrometry at Reynolds. Today, our analytical methods continue to improve and we are continuing to identify compounds at extremely low levels in smoke.

Q. Can you give the Court an example of the difficulties that were encountered in the 1950s in identifying individual mainstream smoke constituents?

A. Identification of smoke constituents was very difficult in the 1950s for two reasons. First, smoke is a very complex mixture composed of thousands of compounds. Second, and more significantly, as I've testified most of the constituents in smoke are present at very, very low levels. Most of the techniques that were available in the 1950s required that you collect enough smoke so that you could extract and process the material using very crude techniques. For example, in analyzing and identifying benzo[a]pyrene, scientists at Reynolds had to smoke about 13,000 cigarettes on a cigarette smoking machine, collect the tar from these 13,000 cigarettes, load it on a three-story chromatography column that we built in a

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stairwell, and collect the fractions for analysis at the bottom. It was a very tedious and difficult experiment to do.

Q. Are those same analytical methods employed today to identify smoke constituents?

A. No. With the modern techniques available today, instead of using 13,000 cigarettes, we can measure benzo[a]pyrene, or other polycyclic aromatic hydrocarbons, with as few as maybe five cigarettes using gas chromatography or liquid chromatography, coupled with mass spectrometry.

Q. To what extent did Reynolds contribute to the identification of smoke constituents?

A. We were the first to identify and publish on the existence of somewhere in the neighborhood of about half of the known compounds in cigarette smoke.

Q. Have the contributions of Reynolds to smoke constituent identification been recognized by scientists outside of Reynolds?

A. Yes. Our contributions have been recognized by the Surgeon General and by other scientists as well.

Q. Let me show you JD-060002 and ask you to identify it?

A. This is an article published in a scientific journal by several Reynolds scientists. This article describes an analytical method for looking at polycyclic aromatic hydrocarbons.

Q. Who are the authors of this scientific article?

A. Bob Cundiff and Peter Markunas. They were scientists with Reynolds for many years.

Q. Where was this published?

A. It was in the Journal of Analytical Chemistry.

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Q. Is that a respected publication?

A. Yes, it's highly respected. The Journal of Analytical Chemistry is published by the American Chemical Society, the premier organization in the United States for chemists.

Q. What is the date of publication?

A. 1963.

Q. What does this article show about Reynolds' research at the time?

A. It shows clearly that Reynolds was researching polycyclic aromatic hydrocarbons. Specifically, we were trying to develop an analytical method, using trinitrofluorenone, to analyze polycyclic aromatic hydrocarbons.

Q. You've testified that there are about 5,000 known compounds in cigarette smoke. Is that number something unique to cigarette smoke?

A. No, it's not. Most organic materials are very complicated. And particularly the added complication of burning that organic material makes it even more complex. Other materials and foods, like coffee, similarly are composed of many compounds.

Q. As a scientist, do you know of any other substance that's been studied as much as cigarette smoke?

A. Cigarette smoke has probably been more thoroughly studied than any other material, because cigarette smoking presents serious health risks.

B. APPROACHES TO SELECTIVE REDUCTION

Q. From a cigarette design standpoint, how do you approach the selective reduction of constituents of smoke?

A. We take a stepwise approach to selective reduction. First, we undertake research to identify and confirm the existence of the target compound, or class of compounds, in

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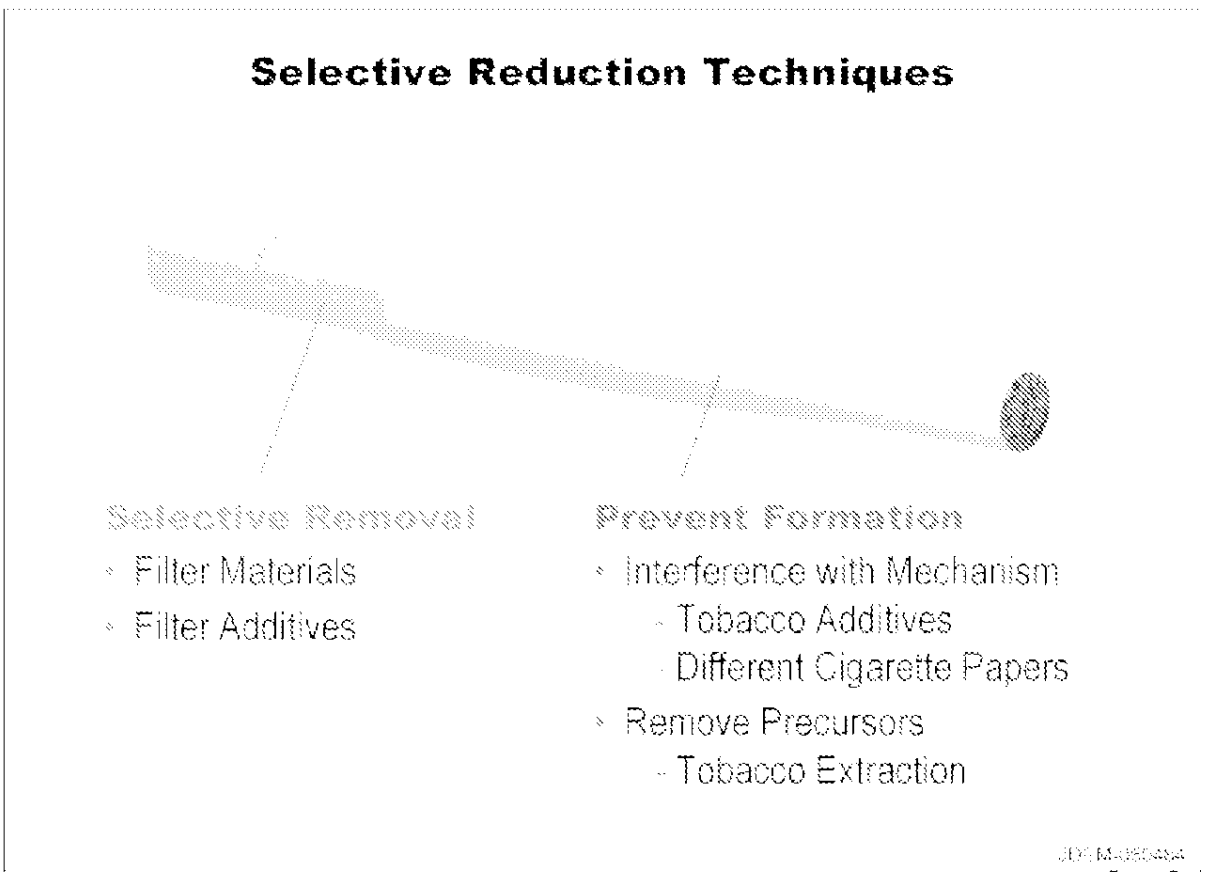
cigarette smoke. Second, we measure how much of the target compound exists in smoke. Third, we seek ways to selectively remove or reduce the compound from smoke.

Q. Do you have a chart that will assist you in explaining approaches to selective reduction after you have identified and quantified compounds of interest?

A. Yes.



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Q. With reference to your chart, how do you approach selective reduction?

A. There are two primary ways to do it: try to prevent the formation of the target compound or try to remove the compound after it is in smoke. To prevent formation, we generally try to interfere with the normal combustion process or remove the precursors to the target compounds. To remove them after formation, we have considered such things as different types of filter materials and filter additives.

Q. Have you had success with selective reduction?

A. Although we've had some success, it is very difficult to accomplish selective reduction, particularly without affecting the taste and acceptability of the product. With about 5,000 known compounds in smoke, and many of those at very low levels, it is a tremendous challenge to simply remove one of those compounds, without affecting everything else.

C. SELECTIVE REDUCTION – BENZO[A]PYRENE

Q. Let's go over some of the notable attempts that Reynolds has made in the area of selective reduction. What was the first compound targeted by the scientific community for selective reduction?

A. Polycyclic aromatic hydrocarbons, and in particular, benzo[a]pyrene. Benzo[a]pyrene is generally abbreviated as "BaP."

Q. What are polycyclic aromatic hydrocarbons?

A. Polycyclic aromatic hydrocarbons are molecules that are comparatively large. They generally have molecular weights of over 200 to 250 units. Structurally, they're combined aromatic rings of carbon and hydrogen, and the number of rings varies. One of the compounds that was of most interest in the early 1950s was BaP. It is a polycyclic aromatic hydrocarbon and it is a non-volatile compound.

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Q. What do you mean by "non-volatile"?

A. Non-volatile compounds reside in the particulate phase of smoke and do not evaporate from the particles as the smoke travels down the tobacco rod and through the filter. On the other hand, volatile compounds are those that do evaporate from smoke particles.

Q. When did Reynolds start the research to try to reduce polycyclic aromatic hydrocarbons, including BaP?

A. In the 1950s.

Q. What happened in the 1950s to cause Reynolds to do that?

A. In the early 1950s, the first successful mouse skin painting studies with cigarette smoke were conducted. The mouse skin painting experiments showed that excess tumors could be generated when cigarette smoke condensate was applied to mouse skin. A number of scientists then started speculating about what in cigarette smoke could account for that finding. One theory, was that BaP and other polycyclic aromatic hydrocarbons might be responsible because BaP, as an isolated compound, had already been shown to cause excess tumors in earlier mouse skin painting studies. Scientists also knew that polycyclic aromatic hydrocarbons were generated in combustion processes in general, so, even though BaP had not yet been identified in cigarette smoke, it was reasonable to suspect that it would be there due to the burning of tobacco. And, it was reasonable to think it might be carcinogenic based on the experiments previously conducted. Therefore, BaP was an obvious target to go after to try to reduce risk.

Q. Was the possible presence of BaP in cigarette smoke discussed by 1950?

A. Yes, by at least 1950, BaP was suspected to be in cigarette smoke. In fact, it was mentioned in a *Reader's Digest* article from 1950.

Q. Let me show you JD-000754 and ask you to identify it.

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A. This is the *Reader's Digest* article that I just referred to that appeared in the January 1950 edition. It is entitled "How Harmful are Cigarettes?".

Q. What does this article say about BaP?

A. On page 1, "What is this substance which we breath into our mouths and lungs in such stupendous clouds? It contains a number of ominous-sounding chemicals. Medical men, however, have not proved a case against them. But two of the chemicals are under grave suspicion: benzo-pyrene, which chiefly affects the respiratory tract, and nicotine."

Q. Earlier, you referred to a stepwise approach that Reynolds takes with respect to selective reduction. Did Reynolds follow this approach with respect to BaP?

A. Yes.

Q. What did Reynolds do to try to eliminate or reduce BaP in cigarette smoke?

A. First, we confirmed the presence of BaP in cigarette smoke. Internally, we had made that finding in about 1956. Prior to that time, there were several reports in the external scientific literature about BaP in cigarette smoke. Second, we were able to determine the level in which it is present in cigarette smoke, and we found BaP to be present in the nanogram per cigarette range. Third, we've had extensive research projects to greatly reduce, or eliminate if possible, BaP and the whole class of polycyclic aromatic hydrocarbons from cigarette smoke.

One of the ways that we tried was to prevent its formation. BaP is not actually present in tobacco; it's formed once the tobacco is burned. We tried to prevent its formation through the use of tobacco additives and the extraction of tobacco. We've looked at a variety of metals, diatomaceous earth, salts, silicas, and other compounds as potential tobacco additives. The theory behind the use of tobacco additives was to reduce the temperature of combustion in the cigarette. If the combustion temperature is reduced sufficiently, you can

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prevent the formation of BaP. While the use of tobacco additives has been technically feasible, it has not been commercially successful.

With respect to tobacco extraction, we conducted radiotracer studies to discover what compounds were the precursors to the formation of BaP in cigarette smoke. From that knowledge, we were able to develop methods to extract those precursors from tobacco. Although we had some technical successes with extraction, it altered the tobacco too much and was not commercially practical.

We also conducted research with filter additives and different filter materials in an attempt to remove BaP after it was formed. This research was also not successful.

Q. Let me show you JD-060507 and ask you to identify it.

A. It's an internal research report by Reynolds scientist, Dr. Jim Harris, and it's dated 1967. The title is, "Control of PAHs In Cigarette Smoke, a Survey".

Q. What is the purpose of this document?

A. To summarize the results of the Reynolds research that had been conducted up until 1967 on the reduction of polycyclic aromatic hydrocarbons, including BaP.

Q. What information is contained in Tables 1 and 2?

A. The tables list the additives that we've explored and placed on tobacco to try to reduce polycyclic aromatic hydrocarbons. The left-hand column contains the name of the additive tested, the middle column reflects the amount of additive used per cigarette, and the right-hand column is the reduction, if any, in polycyclic aromatic hydrocarbons.

Q. What do you conclude about whether the research on the tobacco additives was successful?

A. There was some technical success for a few additives, but many did not even achieve any reduction. If you look at Table 1, for example, you see that adding copper nitrate to

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tobacco resulted in an 84 percent reduction in BaP and adding magnesium nitrate resulted in a 71 percent reduction in BaP.

However, in some cases, we found that the additive itself was also transferred to mainstream smoke, which meant that we were adding new compounds to smoke. That is not a direction we want to go; our job is to reduce and simplify smoke chemistry, not add to it. Also, in some cases, the additives would cause fiery particles to fall out of the burning zone of the cigarette. From a practical perspective, that would not be acceptable to consumers. Overall, despite some isolated technical successes, tobacco additives have not been shown to be effective in a way that could be commercialized.

Q. Was Reynolds the only organization that was doing any research back in the 1950s on BaP in cigarette smoke?

A. No, there were several scientists who advocated this approach. The most notable was Dr. Wynder. He recognized that certain tobacco additives could prevent the formation of BaP. He was particularly enamored with using magnesium nitrate, but later realized that if one adds nitrates to the tobacco, one can possibly increase the levels of certain other problem compounds. So Dr. Wynder ultimately decided that using magnesium nitrate wasn't a viable approach and walked away from it.

Q. Did Reynolds evaluate using magnesium nitrate?

A. Yes. As the tables in JD-060507 reflect, we looked at a number of additives, including magnesium nitrate.

Q. What did Reynolds conclude about magnesium nitrate?

A. Technically, it did reduce BaP somewhat, but it also increased the levels of other compounds like nitrosamines and nitric oxide that resulted from the decomposition of the nitrate. The work illustrated one of the significant shortcomings of selective reduction —

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although one compound or class of compounds might be reduced, the impact on other compounds is unknown or undesirable.

Q. You also mentioned research on BaP with filters and filtration. Was Reynolds able to develop filters that would specifically filter out BaP?

A. No, this approach wasn't technically successful. The reason is because BaP is non-volatile, so it stays in the particulate phase of smoke and can't be selectively trapped by a filter. It can only be trapped if you trap that whole particle.

Q. Referring back to JD-060507, Dr. Harris' summary of Reynolds' work, what does it show about Reynolds' research on filter additives?

A. Table 3 on page 5 lists some of the filter additives we researched and, as it shows, virtually all of them showed no effect. I conclude that the use of filter additives is not an effective way to selectively reduce BaP and other polycyclic aromatic hydrocarbons.

Q. You also mentioned a tobacco extraction process as a research effort to reduce BaP. Please describe the results of that work for the Court.

A. Our research goal was to reduce BaP and other polycyclic aromatic hydrocarbons. As I said, we performed radiotracer studies in which you place radioactive carbons in different places in the tobacco and you try to find out what precursor or what chemical compound in tobacco, ultimately when it's burned, produces the polycyclic aromatic hydrocarbons that are in smoke.

What we found was that the precursors were the long-chain waxes, particularly solanesol and a few other long-chain waxes, that are present in tobacco. When those compounds burn, they cyclize or form rings and ultimately form the polycyclic aromatic hydrocarbon. Once we determined that, our next step was to determine what solvents could extract these precursors from the tobacco. We found a number of different solvents that

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would work, including hexane, heptane, pentane, and mostly very low molecular weight solvents. In the extraction process, we'd take the tobacco, treat it with one of these solvents, like hexane, to extract the waxes, then take the resulting tobacco, process it, and make cigarettes out of it. The cigarettes that were made out of the extracted tobacco did, in fact, generate smoke that was lower in BaP and other polycyclic aromatic hydrocarbons.

Q. Overall, how would you describe how extensive that research project was at Reynolds with respect to BaP?

A. It was a very large project. We even went as far as building a large pilot plant to do the extractions of tobacco.

Q. At the end of the day, did extraction work?

A. Technically, it worked; but, for several reasons, it turned out not to be a viable commercial process. First, once you extract the tobacco, it becomes very brittle. And when you try to make cigarettes on a cigarette making machine, the tobacco pretty much falls apart into dust. Extraction takes out quite a lot of the main components of tobacco. Second, there were significant taste differences between the extracted tobacco and the standard tobacco leaf. And then, third, we found it very difficult and never could really get all of the solvent removed from the tobacco; there were always traces of solvent leftover. As I said before, our job is to remove or reduce smoke constituents, not add to them. Ultimately, we decided that extraction was not commercially feasible.

Q. You earlier testified that the positive mouse skin painting results were theorized to be caused by BaP. Did there ever come a point in time when scientists outside of Reynolds expressed a view about whether BaP was sufficient to account for these results?

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A. Yes. For example, Professor Wynder concluded in the late 1950s that there was not enough BaP in cigarette smoke to account for the mouse skin painting tumorigenicity results. If you recall my earlier testimony, the mouse skin painting studies with pure BaP, as an individual compound, had already been conducted, so scientists knew how much tumorigenicity was caused by a certain amount of BaP applied to mouse skin. Once there was an understanding of how much BaP was present in cigarette smoke, various scientists, including Professor Wynder, concluded that the amount of BaP was insufficient to cause the results seen in the mouse skin painting studies with smoke. That led to the obvious conclusion that there must be something else in smoke that needs to be looked at in addition to BaP.

Q. Let me show you JD-000827 and ask you to identify it.

A. This is a published article from Dr. Wynder in 1959 that appeared in the British Medical Journal. Its title is "Laboratory Contributions to the Tobacco-Cancer Problem."

Q. At the bottom right-hand column of page 318, what does Dr. Wynder conclude about BaP?

A. "A large number of investigators have now identified 3:4-benzopyrene in tobacco smoke condensate ranging up to 2 µg per 100 cigarettes [citations omitted]. It is generally realized, of course, that this amount of benzpyrene is not sufficient to account by itself for the carcinogenic activity of the total tar."

Q. After the conclusion was made about BaP, did Reynolds stop working on trying to reduce BaP?

A. No. We continued, and still continue today, to try to reduce BaP and other polycyclic aromatic hydrocarbons. Once there was an understanding that BaP could not account for the

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mouse skin painting results, we started looking at other compounds and classes of compounds that may be playing a role.

Q. Despite all these obstacles and the research that you just were telling us about, was Reynolds able to make any difference in terms of the amount of BaP in the smoke, or did it stay the same even though Reynolds had done all that research?

A. We've not been able to reduce BaP through selective reduction. We have had major reductions in BaP as a result of a different approach, which I call general reduction.

Q. We will get to general reduction later, but let me follow-up briefly. What has happened to BaP yields over the years as a result of Reynolds' implementation of general reduction into its Winston brand?

A. There was a major reduction. In 1956, the yield of BaP in Winston's smoke was 52 nanograms. And as a result of general reduction techniques, by 1998, the yield of BaP in Winston cigarettes was down to 10 nanograms.

Q. Is Reynolds still trying to reduce BaP today?

A. Yes.

D. SELECTIVE REDUCTION – PHENOLS

Q. As the BaP hypothesis lost emphasis, was another theory advanced to explain how cigarette smoke might cause disease?

A. Yes. The next hypothesis was that there may be some other compound in cigarette smoke that together with BaP was responsible for diseases. In particular, there may be compounds called promoters and/or cocarcinogens that would increase the biological activity of BaP and other polycyclic aromatic hydrocarbons. Scientists then pointed to a large class of compounds called phenols because many scientists considered certain phenols to be

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cocarcinogens. So, under the theory, BaP would be the initiator of the tumor and then compounds like phenols would somehow enhance the activity and be the promoters.

Q. What are phenols?

A. Phenols are aromatic organic compounds that have hydroxyl functional groups.

Q. Did Reynolds begin trying to reduce or remove phenols from cigarette smoke?

A. Yes, we started working on that in the late 1950s.

Q. What did Reynolds do?

A. After we examined the theory very carefully, we first went to the laboratory, and our scientists tried to confirm the identification of phenols in smoke and which phenols are present. The second thing we set out to do was determine the levels of each of the phenols, that is to quantify the levels. Once that was done, we began to seek ways to reduce or eliminate the class of compounds called phenols.

Q. As a consequence, did Reynolds abandon its work on BaP reduction?

A. No, we continued looking for ways to try to reduce or eliminate BaP. But what we did was turn some of our attention to phenols and try to selectively reduce phenols and other promoters.

Q. At what levels are phenols present in cigarette smoke?

A. Many phenols are present in the microgram level, that's a millionth of a gram per cigarette. There are other phenols that are present in the nanogram level.

Q. Are phenols unique to cigarette smoke?

A. No, phenols are in many natural products, including tea and coffee.

Q. What techniques did Reynolds then explore to reduce or eliminate phenols?

A. There were a number of approaches we undertook, including tobacco additives to try to change the combustion process, selective removal through different types of filter

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materials and additives placed in the filter, and we looked at extraction, as well, to try to reduce or remove the precursors to phenol formation.

Q. Let me show you JD-060241. Are you familiar with it?

A. Yes.

Q. What is JD-060241?

A. This is an internal research report by Dr. Andy Laurene, George Young, and Larry Lyerly, all three members of the R&D group at Reynolds. The title of it is, "Factors Which Affect the Phenol Content of Cigarette Smoke," and the date is November 1963. This document is an example of some of the phenol research we were doing at the time.

Q. What information is reflected in table number 9?

A. Table 9 is entitled, "Smoke phenol analysis of Winstons with various filter additives." Then it lists the test number, which is the experimental ID number, the filter additive that was used in the filter, the draft, or how hard it is to draw through that particular experimental cigarette, the cigarette weight in grams, and then the phenol level in the smoke.

Q. You testified that this is one example of Reynolds' phenol research. Approximately how many different tests did Reynolds run in this area?

A. This particular table identifies 43 different filter additive configurations that were evaluated. But I can tell you that we've looked at hundreds of filter and tobacco additives trying to reduce phenols. Basically, the major attacks on the phenol issue were similar to what we did with BaP.

Q. And did any meet with success?

A. Yes, we had some success with some phenols, particularly the more volatile phenols, such as phenol itself and several others. Those compounds, because they're volatile, could be selectively removed by certain types of filters. In particular, the use of cellulose acetate as

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a filter material will selectively remove phenols from cigarette smoke. In addition, if you use a certain type of plasticizer on the filter material to make it firm, such as triacetin or carbowax, those materials will provide further selective reduction of the volatile phenols.

Q. I want to talk about filtration later, but does Reynolds use cellulose acetate filters treated with triacetin in its cigarette brands today?

A. Yes. Cellulose acetate has been used by Reynolds since the 1950s, actually, prior to our having discovered that it selectively reduced certain phenols. All of our filtered cigarettes use cellulose acetate plasticized with triacetin.

Q. Do other cigarette manufacturers use cellulose acetate filters treated with plasticizers, like triacetin, that reduce phenols?

A. Yes, like Reynolds, the other manufacturers have done so for many years and continue to do so.

Q. How did the scientific community react to the selective reduction in phenols achieved by these filter additives?

A. I think there was some recognition that it was small step forward. However, in general, there was little reaction because I think there were additional theories that had begun to emerge. In particular, the scientific community became more focused on yet another theory called the ciliastasis theory, so there was very little excitement at that point.

Q. What happened to the phenol theory?

A. It's actually still there. Along with BaP, the phenol promotion theory is still there, and what the scientific community and medical researchers essentially did was to add a new theory on top of that as well, and that was the ciliastasis theory.

Q. Does Reynolds' work in the area of phenols continue?

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A. Yes, it is an effort that we undertook in earnest in the 1960s, but we've continued it because we develop new ideas, new types of filter additives, and new ways of trying to selectively reduce phenols. So the work has continued.

E. SELECTIVE REDUCTION – CILIASTATS AND THE CARBON FILTER

Q. You mentioned the ciliastasis theory. What is that?

A. The next major theory that emerged after phenols was the ciliastasis theory. And that theory suggests that there may be some compounds in cigarette smoke that will disable or somehow temporarily stop the action of cilia that are in the upper respiratory tract. The cilia are part of the clearance mechanism of the lung and normally beat in unison to remove material from the lung. Under the ciliastasis theory, cigarette smoke impairs the beating of the cilia, resulting in a longer contact time for smoke particles with lung tissue.

Q. Were ciliastatic compounds found to be present in cigarette smoke?

A. Yes, there are a number of ciliastatic compounds, or "ciliastats," present in cigarette smoke at very low levels.

Q. Are ciliastats unique to cigarette smoke?

A. No, they're not. Many of the ciliastats are from classes of compounds called aldehydes and ketones. Aldehydes are chemicals that have a carbonyl function with hydrogen off of the carbon. Various aldehydes are present in many foods and in the air we breathe. Nitric oxide is also thought to be a ciliastat. That's present in air pollution.

Q. What was Reynolds' response to this ciliastasis theory?

A. Again, we sought to identify those compounds that were thought to be ciliastats, we quantified the levels to determine how much was present, and then sought ways to reduce or eliminate them.

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Q. What techniques were used by Reynolds to reduce or eliminate ciliastats?

A. We took a number of different approaches, again using tobacco additives, but more particularly using filter additives to try to reduce these ciliastats.

Q. Has Reynolds done anything to try to reduce or eliminate aldehydes in particular in the cigarette smoke?

A. Yes, we have. Over many years we've looked at various ways to try to reduce aldehydes. The reason that we've looked at that class of compounds is because many of them are irritants. And irritation is thought by some scientists to be involved in cancer formation or tumor formation. Some aldehydes are thought to be carcinogenic. So, the class of aldehydes has been a big target, and we've looked at many ways to reduce aldehydes, including using certain additives in the tobacco to try to change the combustion process and reduce their formation. We've looked at filter additives to try to remove aldehydes from the smoke. Some filter additives, such as certain carbon, ion-exchange resins, and other types of materials, can selectively remove volatile aldehydes.

Q. Have Reynolds scientists ever published on aldehydes and how they may be selectively reduced?

A. Yes, we have.

Q. Let me show you JD-062181 and ask you to identify it.

A. This is a publication by Reynolds scientists, Dr. Andy Laurene, Larry Lyerly and George Young. The title of it is, "Direct Vapor Chromatographic Determination of Acetaldehyde, Acrolein, and Acetone In Cigarette Smoke," and it was published in the journal Tobacco Science in 1964.

Q. Does this article describe some of the work that Reynolds was doing on selective reduction of ciliastats?

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A. It does. It describes an analytical test method that can be used to measure amounts of acetaldehyde, acrolein and acetone in cigarette smoke. One has to be able to measure what's in the smoke before you can actually see that you've reduced it.

Q. Dr. Townsend, please read the first paragraph of JD-062181 into the record.

A. "The selective filtration of cigarette smoke has been a matter of continuing interest. Filters containing activated carbon have shown promise, particularly with respect to the selective removal of some of the components of the vapor phase. The present paper describes a method for the determination of some of these components. Results are also given for various analyses, including data on a blended cigarette with a bonded carbon filter."

Q. And what does JD-062181 report about the use of a carbon filter?

A. Table 1 on page 153 shows that test cigarette E, the one with the carbon filter, reduced acetaldehyde yield by about 75%, acrolein yield by about 85%, and acetone yield by about 90%, as compared to an unfiltered cigarette.

Q. Did Reynolds ultimately market a cigarette that responded to the ciliastasis theory?

A. Reynolds and all of our competitors had a number of products that reduced some of these ciliastats.

Q. What was the product that Reynolds had marketed?

A. The brand name was Tempo, which was a carbon filtered product. We introduced Tempo in 1964. Many people call it charcoal filtered, although it was really activated carbon. The activated carbon efficiently reduces the volatile aldehydes and ketones of the carbonyl group.

Q. Was Reynolds the only domestic manufacturer to sell a carbon filtered cigarette?

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A. No, at one time or another, all of the major domestic manufacturers have offered carbon filtered cigarettes. The first major brand was a cigarette called Lark that was introduced by Liggett in the early 1960s.

Q. How did carbon filter cigarettes do in the marketplace?

A. There was some initial interest among smokers. There was a fairly rapid increase in the share of market of all carbon filters, including our product Tempo. And it was spurred primarily by popular press articles that suggested that these carbon filters do remove a number of compounds. So there was initially some interest. But the taste characteristics are different than traditional cigarettes without carbon filters. Carbon filters ultimately failed in the market, and the reason is because American consumers really don't care for the taste of charcoal filtered cigarettes or carbon filtered cigarettes.

Q. And did you prepare a chart, Dr. Townsend that depicts the decline of consumer acceptance of carbon filters?

A. Yes, I did.

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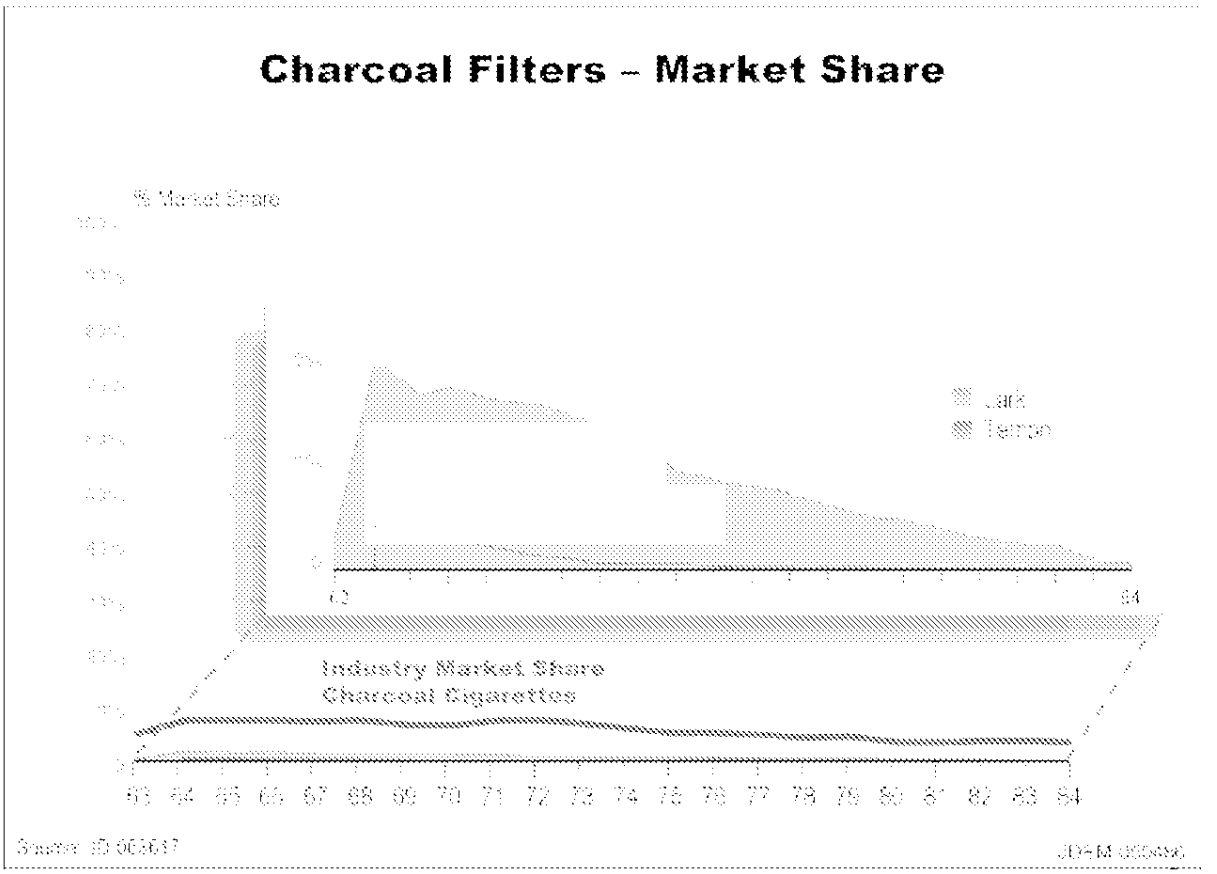

Q. And what is the significance of this chart to your opinions about carbon-filtered cigarettes?

A. What this shows is the market share for two particular charcoal filtered cigarettes and the total market share for all charcoal filtered cigarettes in the U.S. market over time. The charcoal filtered cigarettes were introduced in the early 1960s as a result of the ciliastasis theory. You will notice that there was a slight increase in their share of market. If you break out some individual brands, the Reynolds product called Tempo initially got somewhere around about 0.4 percent share of the market. So it's quite small. However, there was an initial rise in the market share of that product, and then a gradual fall off over the next few years.

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Lark was the best selling charcoal filtered cigarette, and it's still on the market today. It has a minuscule share of the market, but it's still out there. After introduction, Lark rose to nearly two percent of the market, and then gradually declined.

So, overall, there was some interest in charcoal filtered cigarettes, but it just did not last. Smokers tried those products, but just did not stick with them because they didn't like them.

Q. Are there any charcoal filter brands left on the market today?

A. There's a couple. There is Lark, which I've mentioned, and Tareyton which uses an activated carbon dispersed in a cellulose acetate filter. Both of those have miniscule market shares.

Q. What's the lesson for a cigarette designer such as yourself regarding what has transpired in the marketplace with charcoal filtered cigarettes?

A. The adverse reaction to the taste of these cigarettes was the reason that they weren't accepted by the American smokers. Because the activated carbon efficiently removes carbonyls, as well as other compounds, it changes the balance of the taste. The taste characteristics are different. For some smokers outside the United States, they prefer carbon filters, but U.S. smokers, for some reason, just haven't accepted the taste difference.

So I'd say that the lesson to a cigarette designer or product developer is that consumer acceptance is essential if you're going to be successful in the marketplace with cigarette design. Regardless of the potential merits of a design innovation, if smokers do not accept that product, then you've not been successful.

Q. Is Reynolds still working on the reduction of ciliastats today?

A. Yes. We've actually looked at different types of carbon filters. We currently have a large research project right now to see if we can maintain the constituent reductions and

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eliminate the off-taste that is characteristic of typical carbon filters. We've made progress in that direction and we're still working on it.

Q. Are you referring to a research project at Reynolds called "EW"?

A. Yes.

Q. The Court has already read and heard testimony from Dr. Jeffery Gentry regarding EW and his work on that cigarette. Did you also work on EW?

A. Yes, as did other scientists who reported to me, like Dr. Gentry.

Q. Please remind the Court of the time frame for EW's development and test-marketing.

A. EW development principally occurred in the early-to-mid 1990s. We introduced it into test market in Oklahoma in April, 1995. EW remained in test market until the summer of 1997.

Q. While you were working on EW, did you personally participate in meetings with upper management regarding its status?

A. Yes.

Q. Did that include meetings with Andy Schindler?

A. Yes, I was part of several meetings with Mr. Schindler regarding EW.

Q. Do you understand that Mr. Schindler testified in this case?

A. Yes.

Q. What did Reynolds hope to achieve with EW?

A. Upper management, and especially Mr. Schindler, wanted to be able to make a health claim for EW, but they knew we also had to be able to prove it. The problem was that there was not a consistent view within R&D regarding EW. There was significant debate within R&D as to whether EW was a safer cigarette and, even if it was, whether we could prove it.

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Some scientists, like me, personally believed at the time that EW probably reduced disease risk. Others, including one of our top toxicologists, were concerned by the fact that there were increases in certain compounds that were reported tumor promoters and so they were not convinced that EW offered a benefit. It was this debate that prevented R&D from providing Mr. Schindler and upper management with a singular recommendation as to what EW represented. I vividly recall several meetings with Mr. Schindler in which he expressed his frustration.

Q. When Reynolds ultimately put EW into the test market, did it make any health claims in its advertisements?

A. No.

Q. Apart from your personal view as to EW's potential, did you believe at that time that Reynolds had sufficient data to substantiate an advertising claim that EW was a safer cigarette?

A. No.

Q. In hindsight, do you still believe that the original EW probably reduced disease risk?

A. As marketed in the mid-1990s in Oklahoma, no.

Q. Why not?

A. We determined that the smoke chemistry reductions achieved by EW under FTC smoking conditions did not hold up under more intense puffing. So, there are serious questions as to whether that particular execution of EW would offer any health benefit as it would be used by smokers.

Q. How do you feel about Reynolds' decision not to make health claims with EW?

A. Obviously, the right decision was made.

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Q. Did Reynolds abandon EW after it was withdrawn from the market?

A. No. We took the product out of test market and went back to the laboratory. We developed a new filter design with improved performance at more intense puffing conditions as compared to the original EW. As of the time of my retirement, we were still working on the technology. We were conducting tests to evaluate the most recent prototype, including tests with smokers that we hope will show that the improved EW offers the potential to reduce risk. In addition, because it is a charcoal-filtered cigarette, we continue to work on its consumer acceptability.

F. SELECTIVE REDUCTION – VOLATILE AND TOBACCO SPECIFIC NITROSAMINES

Q. Let's move on to another specific family of constituents of cigarette smoke that has been the subject of this trial. What are nitrosamines?

A. Nitrosamines are a class of compounds where the nitric oxide molecule, NO, is bound with a secondary amine, so it forms a very reactive compound that is called a nitrosamine. Secondary amines and nitric oxide can react in many different systems.

Q. Are nitrosamines found only in tobacco or cigarette smoke?

A. Some are unique to tobacco and its smoke. Tobacco-specific nitrosamines, or TSNAs, are found only in tobacco or cigarette smoke because they are composed of nitric oxide bound with the secondary amine on the nicotine molecule or a nicotine degradation product. But, volatile nitrosamines, or VNAs, are found in many consumer goods, including bacon, beer and other materials.

Q. How many TSNAs are there?

A. Eight have been identified so far as possible smoke constituents. Seven have been positively identified in cigarette smoke.

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Q. Are nitrosamines, including TSNAs, carcinogenic?

A. Some are thought to be, yes. In particular, NNK, is thought to be especially carcinogenic.

Q. Has Reynolds done anything to address nitrosamines and TSNAs?

A. Yes, we have done a number of things. As usual, we first identified, then quantified nitrosamines in cigarette smoke. We developed a test methodology so that we could analyze nitrosamines at the very low levels in which they are present. We then conducted quite a lot of research to try to figure out how nitrosamines are formed in tobacco. In addition, we've had efforts to selectively reduce both TSNAs and VNAs. In the case of VNAs, we found that cellulose acetate filters, and particularly cellulose acetate filters that have triacetin as a plasticizer, can selectively reduce VNAs. We've also made substantial progress in reducing TSNAs.

Q. How do nitrosamines get into tobacco or tobacco smoke?

A. Nitrosamines aren't present in tobacco when it comes out of the field. The VNAs are formed during the burning of the tobacco. The TSNAs are actually formed during the curing of the tobacco.

Q. What do you mean by "curing of tobacco"?

A. The curing process is essentially a drying and aging process for tobacco done by farmers after harvesting the green tobacco leaves. Curing causes some chemical changes that ultimately improve the taste and flavor of tobacco smoke. Various types of tobacco are cured in different ways. For example, with flue-cured tobacco, the farmer will take the green tobacco fresh out of the field, put it in a barn that's closed, and then there are burners that heat that barn and the farmer will adjust the temperature gradually upward over about a two-day period, at which point the tobacco has dried and cured. The leaf becomes yellow instead

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of green. Alternatively, burley tobacco is generally air cured and what that means is that the tobacco is placed in open barns and left to cure and dry without artificial heat.

Q. Has Reynolds made any discoveries about changes that can be made to the curing process to reduce TSNAs?

A. Yes.

Q. What discovery did Reynolds make?

A. We knew from prior research that most of the TSNAs in flue-cured tobacco are formed during the curing process. But despite years of effort, we did not know why. In the late 1990s, we figured it out. During curing, tobacco farmers heat the tobacco in the barn using propane burners and they vent the exhaust gas of the propane burner directly into the barn. The propane exhaust gas contains nitric oxide and that's what reacts with nicotine to form most of the TSNAs that were present in flue-cured tobacco. We conducted small scale tests in 1998 and field trials with tobacco farmers in 1999 that confirmed that if those exhaust gases are excluded from the tobacco barn by the farmer, over a 93% reduction in TSNA levels can be achieved. So, our discovery was putting together all of the pieces of this complex puzzle to explain the mechanism of TSNA formation and how that could be remedied. And, Reynolds was the first to report on that mechanism.

Q. What was the practical implication of this discovery?

A. What it meant was that if we could convince flue-cured tobacco farmers to change their curing practices, and specifically to what is called a heat exchange, or indirect-fire, method that excludes the propane exhaust gases from tobacco, we could substantially reduce TSNAs in our commercial cigarettes without any sacrifice in consumer acceptability.

Q. What did Reynolds do after it made this discovery?

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A. We disclosed our findings publicly. One of the first things we did was to invite scientists from our major competitor companies to our facilities, we showed them all of our data, and suggested to them that they actually work with us to implement this major change among farmers across the growing regions in the United States.

We also prepared scientific papers that were presented at CORESTA and TSRC. Ultimately, we published our findings in the peer-reviewed scientific literature.

In addition to the public disclosure, we contracted directly with tobacco farmers and provided financial assistance to them so that they could convert their existing barns to the heat exchange system. We also made it clear that we were going to buy only tobacco produced by this heat exchange method, so that all of the cigarettes we make would contain the flue-cured tobacco with dramatically reduced levels of TSNAs.

Q. If you're in competition with everyone, why would you make a big discovery like this public?

A. We saw no competitive advantage to keeping this finding to ourselves. Reducing that one class of compounds would never get us to a cigarette that we could prove was, in fact, a safer cigarette, and thus we wouldn't get a competitive advantage with this technology alone. However, we still felt an obligation to implement it. And we felt like the whole industry ought to make this change.

Q. Doctor, please identify JD-060117, JD-060141 and JD-060138?

A. These are press releases from Reynolds in 1999 about the discovery we made on TSNAs. JD-060117 describes our discovery, JD-060141 announces a scientific presentation that I would be giving at CORESTA about the details of our discovery, and JD-060138 indicates our intent to use only low TSNA flue-cured tobacco in our cigarettes.

Q. You also mentioned scientific presentations. What were those?

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A. There were three. I, or one of my colleagues, made presentations at a CORESTA meeting in Austria in September 1999, the TSRC also in September 1999, and a CORESTA meeting in China in October 1999.

Q. Has Reynolds work on trying to reduce TSNA's ended with its discovery?

A. No, it hasn't ended there. We have been very successful with flue-cured tobacco. Another blend component, burley tobacco, which is grown in mountain areas, also has TSNAs. We are doing field trials and experiments now to try to figure out how we can reduce the levels in burley tobacco. We're making significant progress, but we still have work to do.

Q. What progress have you made on burley?

A. We've found that the spacing of the tobacco plant during curing makes a big difference in TSNA levels. With appropriate spacing, an approximate 75% reduction in TSNA levels can be achieved. We've developed some proposed guidelines that we've communicated to CORESTA. We are currently working to get farmers to adopt these new guidelines.

Q. In addition to the chemistry of TSNAs that you've described, has Reynolds done biological testing on the low TSNA tobacco?

A. Yes, we have. We've done extensive biological testing with cigarettes made with this low TSNA tobacco. We found no difference in *in vitro* testing. That's cellular testing in the laboratory. We found no difference in animal skin painting studies and in an animal inhalation study where we look at irritation in the respiratory tract. So despite a major reduction in TSNAs, we found no biological changes that resulted from it.

Q. What does that mean to you in terms of whether the use of low TSNA tobacco makes cigarettes safer or not?

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A. Currently, based on the available data, there's no indication that there would be any risk reduction by just removing TSNAs. What that means to me is, to be successful in reducing the risk of cigarettes, one really has to look at a broad range of compounds, not just one particular compound.

Q. If there is no demonstrable risk reduction, why did Reynolds spend the money to help farmers convert their barns and why is Reynolds using the low TSNA tobacco?

A. We felt that even though we've seen no reduction in biological activity, TSNAs are still important targets because they are very reactive molecules and some scientists believe that they're among the most significant carcinogens in smoke. If we've got a way to reduce them, we're going to do it. And that's what we're doing. All of the flue-cured tobacco that Reynolds is buying now is low TSNA, and it's going into all of our products.

Q. What about your competitors; do you know if Lorillard, Philip Morris and Brown & Williamson also switched to using low TSNA flue-cured tobacco?

A. Yes, they did.

G. SELECTIVE REDUCTION – CARBON MONOXIDE AND OXIDES OF NITROGEN

Q. Other smoke constituents that have been discussed in this trial include carbon monoxide, or CO, and oxides of nitrogen, or NO_X. Has Reynolds done any research to try to reduce or eliminate those two components?

A. Yes. We've conducted quite a lot of research for years on carbon monoxide and nitrogen oxides. And, in particular, we've looked at, again, additives to tobacco to try to reduce the formation of these. We've looked at additives in the filter to try to remove them from the smoke. And then we've implemented various general reduction techniques as well that affect all smoke constituents, including CO and NO_X.

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Q. Why has Reynolds tried to reduce the yields of those compounds in cigarette smoke?

A. Because they are both compounds of concern. CO, for example, can bind with hemoglobin and reduce oxygen transport in the body. Some NO_X are fairly reactive, meaning they can react with other compounds in the body or in the smoke. For example, as I previously testified, nitric oxide, an NO_X, reacts with secondary amines to form nitrosamines. So reducing those compounds is important to do.

Q. Please describe what Reynolds has done in terms of trying to selectively reduce CO.

A. The first approach was to use additives on tobacco to prevent formation. The second approach, which actually looked more viable, was to use certain filter additives or different types of filter materials to remove the compounds from smoke. We researched additives and filters to either absorb or adsorb CO from the smoke stream, or to act as a catalyst to convert CO to carbon dioxide.

Q. How extensive was Reynolds' efforts with respect to the selective reduction of CO?

A. It was a very extensive effort that spanned many years, involved a number of different scientists looking at all those approaches, as well as looking at design changes in the cigarette itself to reduce CO.

Q. Were you, yourself, involved in the CO research?

A. Yes. It's one of the first projects I had when I came to Reynolds in 1977.

Q. What has Reynolds found with respect to the selective reduction of CO?

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A. It is very difficult to do. Some of the materials we investigated simply were not effective at all. Other materials, like some of the catalysts we examined, were only effective in the first puff or two on the cigarette and then they did not work after that.

Q. Why didn't the catalysts work to reduce CO?

A. In theory, a catalyst should work by having CO adsorb, or stick, to it as the smoke stream passes by. The problems we had were that other things, such as the tar particles, carbon dioxide and moisture, would preferentially "stick" to the catalyst and deactivate it.

Q. Has Reynolds nonetheless been able to reduce the CO yields of its cigarettes over time?

A. Yes, through general reduction techniques.

Q. We'll talk about general reduction later. Let's move on to NO_X. What has Reynolds done to try to reduce NO_X?

A. We've undertaken similar approaches to NO_X reductions that we took for CO. Specifically, we've tried tobacco and filter additives. We have also looked at various processed tobaccos and proprietary tobacco blending to try to achieve reductions in NO_X. As with the CO work, none of this work was terribly successful, although we did see some minor reductions with specialty tobacco blends.

Q. Is Reynolds still trying to find other ways to reduce CO and NO_X?

A. Yes.

Q. And so let me ask you, then, with respect to these compounds, CO and NO_X, what's the bottom line with respect to Reynolds' research?

A. We've not been able to find commercially viable filter additives or tobacco additives that would substantially reduce them selectively. We have, however, found general reduction techniques that significantly lower both CO and NO_X.

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H. SELECTIVE REDUCTION – METALS AND RADIOISOTOPES

Q. Still other compounds discussed in this trial have been metals and radioisotopes. Has Reynolds attempted to selectively reduce metals and radioisotopes?

A. Yes.

Q. Does Reynolds add metals or radioisotopes to its cigarettes?

A. No, we don't. The metals arise primarily through the growing process. They're absorbed through the roots from the ground, so there can be very low levels of compounds like arsenic, magnesium, and cadmium, in the tobacco leaf. During the combustion of the tobacco, these metals are not volatile at all and small amounts of the metal can be entrained in, or swept up by, the smoke stream out of the cigarette into the mainstream smoke. So they're actually in the particulate phase of smoke.

As for radioisotopes, there is a radioisotope that is a metal that is actually common in the air and ultimately can land on tobacco as well as other agricultural products. That isotope, called polonium 210, can be present in cigarettes at extremely low levels under some conditions.

Q. What's the amount of metal that's in cigarette smoke?

A. Well, they are typically present at the nanograms per cigarette level.

Q. How much polonium 210 is in cigarette smoke?

A. It is present in extremely low levels, about 1 femtocurie per milligram of tar.

Q. And what has Reynolds done with respect to selective reduction in trying to reduce the amount of metals and radioisotopes in the cigarette smoke?

A. We've looked at several things and really haven't been very successful. Metal compounds and radioisotopes are generally not volatile at all and so selectively removing them is, I think, not likely to ever be successful. Thus, what we continue to look at is general

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reduction, and we've seen major reductions in yields of metals and radioisotopes in smoke as a result of those techniques.

I. SUMMARY OF SELECTIVE REDUCTION

Q. In addition to theories about BaP, phenols, ciliastats, TSNAs, CO, NOx, metals and radioisotopes, have there been theories about the possible role of other smoke constituents with respect to smoking and health?

A. Certainly there have been others. We know of about 5,000 compounds in smoke. I've said that several times. And, it is not just the ones we've discussed so far that have suspected toxicity or have been identified as a potential contributor to the inherent health risks of smoking. For example, we think 1,3-butadiene, an unsaturated hydrocarbon, is an important one based on toxicity analyses that we've conducted and the reports on it in the scientific literature. We're working on reducing it along with many other compounds.

Q. At any point in time has there ever been a consensus in the scientific community about what particular ingredient or substance ought to be reduced or eliminated?

A. There's never been a complete consensus. I think scientists have pointed at a number of compounds that need to be reduced or eliminated, but there's never been a consensus that, for example, TSNAs are the key ones or that aldehydes are the key ones. I think there have been a variety of hypotheses. I think all of those compounds are on the list to be reduced or eliminated. And that's the approach that we at Reynolds have taken in selective reduction. You hit as many compounds as you can, as many classes as you can, and then there's a different direction in general reduction that has shown some significant success in that as well.

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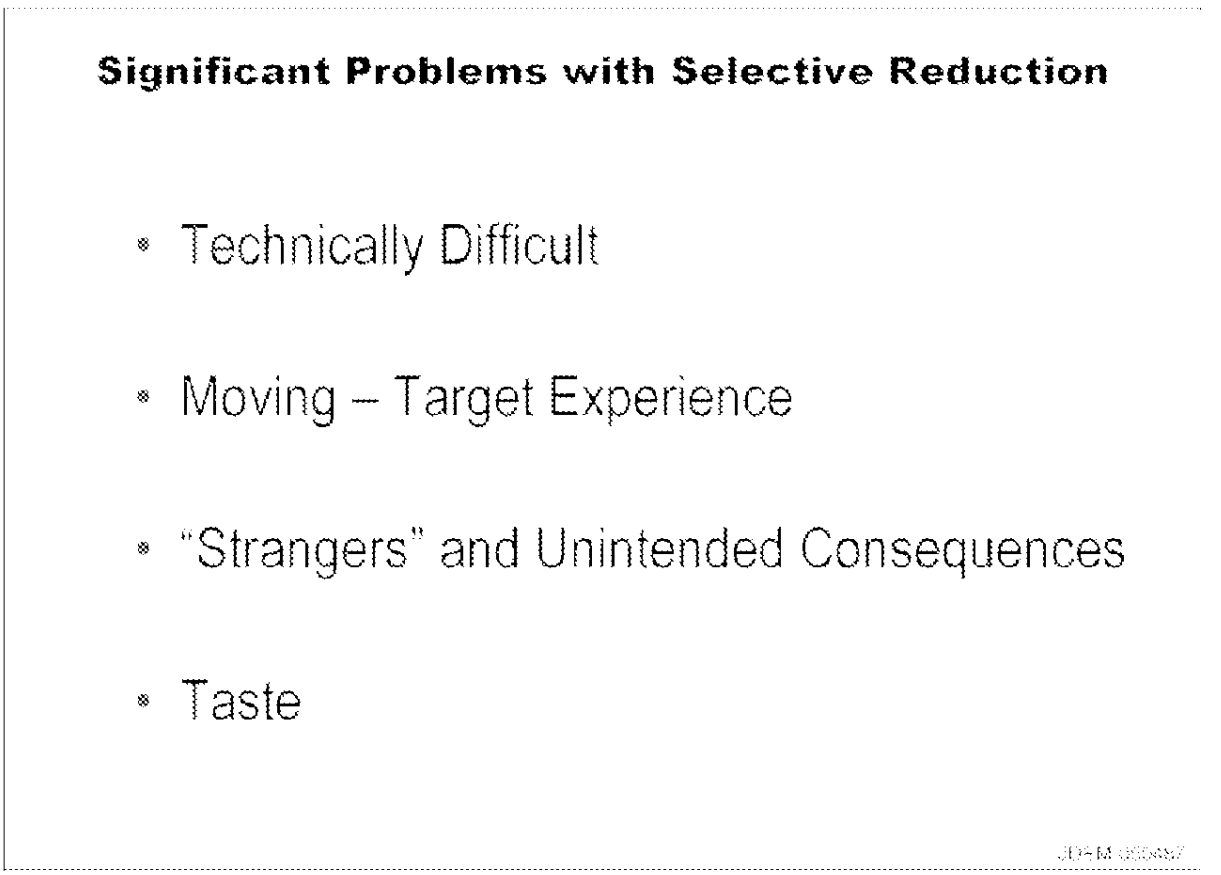
Q. Have you prepared a chart that will summarize the difficulties that Reynolds has encountered over the past 50 years with respect to selective reduction?

A. Yes.



Q. With reference to your chart, please briefly describe the major difficulties with selective reduction.

A. Our experience with selective reduction is that, first of all, it's technically difficult. It's really tough to go into a complex mixture with a scalpel and say, 'I'm going to carve out and remove only BaP, or only polycyclic aromatic hydrocarbons.' It's technically very difficult.

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The second issue is what I call the moving target experience. Scientists initially believed that BaP and polycyclic aromatic hydrocarbons were of concern. The scientific community then concluded that phenols were probably involved, so then the interest shifted that way. And then the interest shifted to ciliastats, or aldehydes, and so on. I'm not suggesting that any of the scientists walked away from these hypotheses, but there are just so many changing hypotheses that it makes it very difficult to focus our selective reduction efforts and be successful.

The third difficulty with selective reduction is that in some cases the techniques we are researching may result in new compounds in smoke or increases in other compounds of concern.

Lastly, and very importantly, selective reduction often affects taste and consumer acceptability. One of the things that we've found is when we're successful in removing a compound or reducing a compound greatly, it can upset the balance of the taste. That is something smokers generally don't accept. Carbon filters are an example of that phenomenon.

As a result of all of these issues, selective reduction has not proven so far to be an effective approach to reducing the risks of smoking in cigarettes that people will actually smoke.

Q. Are these issues with selective reduction unique to Reynolds?

A. No, they've been discussed in the published literature for decades. We've had these problems, our competitors have had these problems, and so have scientists outside of the cigarette companies that have tried selective reduction.

Q. Does Reynolds still work on selective reduction techniques?

A. Yes, we do.

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Q. If you have all these problems, why are you doing it?

A. Because I still believe that there's success to be had with selective reduction, particularly by looking at not just one particular class of compounds, but several classes. I think it can be done and we're working very hard on it.

V. RISK REDUCTION THROUGH TOBACCO SUBSTITUTES

Q. Dr. Townsend, let's turn to another research effort to try to reduce risk and that's a method you referred to earlier as tobacco substitutes. What are "tobacco substitutes"?

A. The potential use of tobacco substitutes is an interesting area. The idea behind tobacco substitutes is to look for some combustible material, other than tobacco, that generates simpler chemistry when it burns. One could then blend that material with tobacco and hopefully reduce the health risks of smoking. At Reynolds we've looked at quite a few tobacco substitutes and evaluated their performance by themselves or blended with tobacco to see if that would simplify or change the chemistry in a beneficial way.

Q. Let me show you JD-060150, JD-060519, JD-060520, and JD-061328. Please identify these exhibits.

A. They are research reports summarizing some of the early work Reynolds conducted on various tobacco substitutes.

Q. Have you helped to prepare a chart regarding the different potential tobacco substitutes that Reynolds investigated?

A. Yes.

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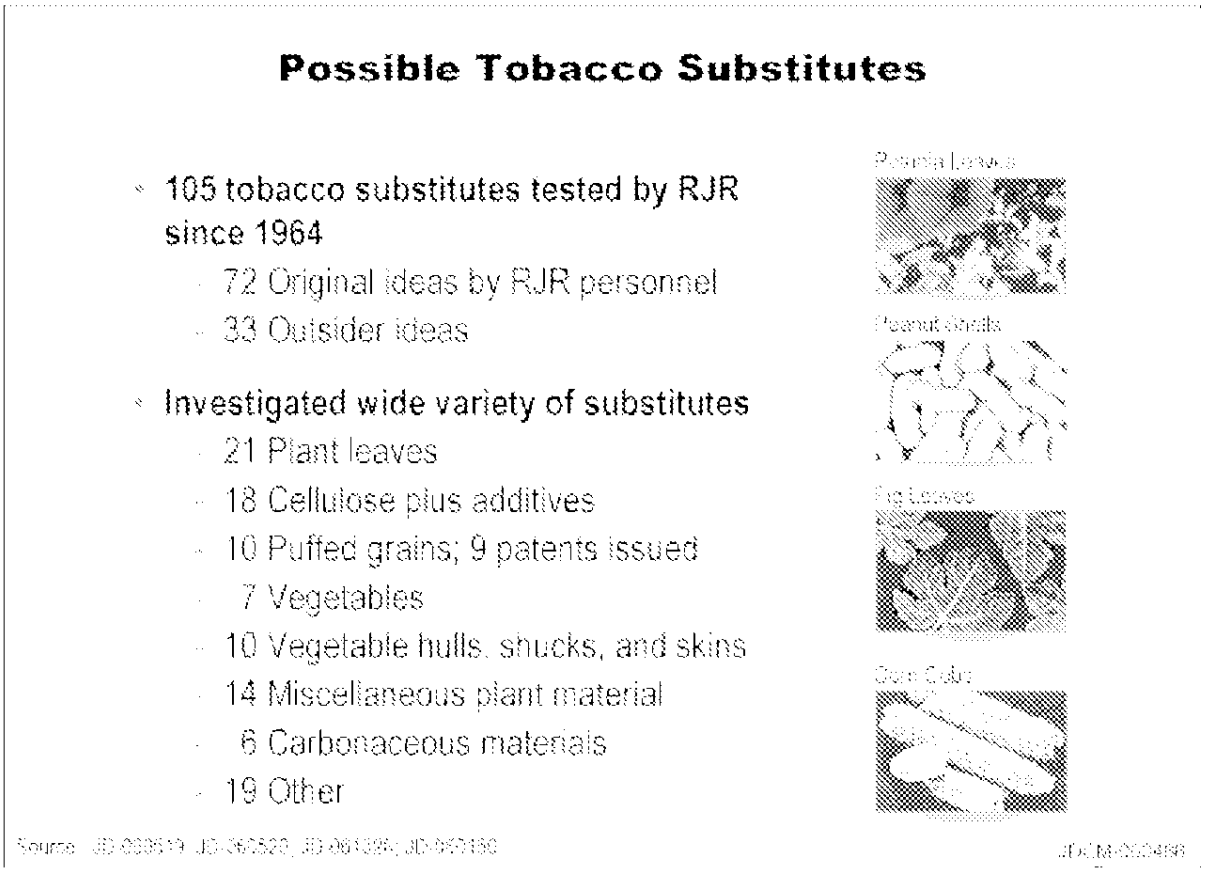

Q. Using your chart, please explain what Reynolds has done in the area of tobacco substitutes.

A. This chart summarizes much of the work on tobacco substitutes that we've done at Reynolds. When I made this chart, we had tested over a hundred different types of tobacco substitutes. Approximately 72 of them were ideas that we generated, and 33 were ideas that other people outside of Reynolds generated. The possibilities spanned a whole variety of different types of materials, including different plant leaves and vegetables, as well as synthetic materials.

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One of the things that we thought was very interesting to pursue was puffed grains and puffed rice because they have very simple chemical compositions. Carbonaceous materials were also looked at very extensively.

Q. Has Reynolds been successful in terms of developing a tobacco substitute?

A. No, not really. The reason is due to the fact that to greatly simplify the chemistry, one needs to put a lot of a substitute in the tobacco blend. But if you use a lot, the taste characteristics are significantly affected. If you use only a little bit and have more acceptable taste, then you don't really affect the smoke chemistry yields very much.

Q. Was Reynolds alone in exploring tobacco substitutes?

A. No, I believe that most of the major manufacturers have investigated substitutes. In fact, there have been commercial products with substitutes introduced into the marketplace, primarily in Great Britain. In the United States, we've had several small manufacturers introduce substitute cigarettes with things like lettuce leaves or cocoa bean hull cigarettes. There have been a number of different tobacco substitute products that were introduced and frankly they failed in the market.

Q. What are the problems with tobacco substitutes?

A. With consumers, they mainly fail because of the adverse taste characteristics. In addition, in the case of lettuce leaves or even cocoa bean hulls, when you burn them, you still generate very complex chemistry. I think the future, if there is one for tobacco substitutes, is to look at very simple materials as we've done, like starches, or carbonaceous materials, which are materials that are essentially preburned.

Q. Has Reynolds abandoned research into tobacco substitutes?

A. No, we haven't abandoned it. We're continuing to work on tobacco substitutes today.

Q. Why?

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A. Just because we haven't been successful so far with a particular approach, like tobacco substitutes, that doesn't mean that we're going to walk away. It is a reasonable approach to try to reduce risk.

VI. RISK REDUCTION THROUGH GENERAL REDUCTION

Q. Dr. Townsend, let's turn to another approach that you identified for trying to reduce the risks of smoking. What is general reduction?

A. As opposed to targeting one compound or class of compounds, general reduction is an attempt to reduce the yields of all of the compounds in smoke pretty much to the same degree.

Q. When did Reynolds begin to do research on general reduction techniques?

A. In the early 1950s, pretty much in parallel with all the work on selective reduction.

Q. Has Reynolds been successful in reducing tar and nicotine yields through general reduction?

A. Yes, general reduction has been very successful in the market. We've seen more than a 60 percent reduction in total yield from cigarettes on a sales-weighted average basis through the incorporation and consumer acceptance of general reduction techniques.

Q. What do you mean by a 60 percent reduction in "yield"?

A. I mean a reduction in the total amount of mainstream smoke generated by a cigarette as measured under standardized machine smoking conditions. Since 1967, the Federal Trade Commission has prescribed the standardized conditions that the cigarette manufacturers use to measure tar, nicotine and more recently carbon monoxide yields. Prior to 1967, there was no government mandated machine smoking procedure, but Reynolds did have its own standardized method that it used, as did other organizations, such as *Reader's Digest* (see JD-000748) and *Consumer Reports*.

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To be clear, in this written testimony, unless stated otherwise, any reference I make to smoke yields should be interpreted to mean those yields as measured by the Federal Trade Commission standardized method, or, for the time period prior to 1967, other comparable methods.

Q. Dr. Townsend, there has been much testimony in this case regarding what are called "low tar" and "lower tar" cigarettes. Is it the general reduction approach that led to the development of "low tar" and "lower tar" cigarettes?

A. Yes.

Q. Before getting to the particular techniques employed to achieve general reduction, I want to ask you to provide the Court with some background information. First, what is the theory behind general reduction as a potential means to reduce the health risks of smoking?

A. One of the basic tenets of toxicology is that "less ought to be better." Since the 1950s, the epidemiology has suggested a dose response relationship between smoking and the risk of disease. Put another way, the more smoke one is exposed to, the greater the risk of contracting a disease associated with smoking. The theory behind general reduction is that if the smoke yield is reduced, a smoker's exposure to smoke will be reduced, and there will be a decrease in risk. In other words, "less ought to be better."

Q. Since the 1950s, have various members of the medical, scientific and public health communities expressed their views regarding the merits of general reduction?

A. Yes.

Q. Please provide some examples of the recommendations that have been made regarding general reduction.

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A. The August 1957 *Reader's Digest*, at page 44, reported: "Dr. Ernest L. Wynder of the Sloan-Kettering Institute states that, for practical purposes, a filter tip capable of filtering out 40 percent of the tar would be a step in the right direction. … 'Such a filter tip,' Dr. Wynder says, 'placed on a regular-size cigarette which normally yields 30 milligrams of tar in its smoke, would reduce the smoker's tar exposure to about 18 milligrams. A reduction to that level, as shown both by animal experiments and human statistical studies, would be a significant reduction in cancer risk.'". [JD-000826] As a brief aside, Reynolds' cigarettes and those of our competitors have far exceeded the 40% reduction in tar yields that Dr. Wynder called for in 1957. Indeed, the average tar and nicotine yields today are about 60% lower than they were in the 1950s.

In 1967, Drs. Wynder and Hoffmann, in their treatise at page 535 stated: "[A]s a most important first step toward the reduction of the tumorigenic and cilia-toxic activity of cigarette smoke, the cigarette industry should be encouraged to manufacture and promote cigarettes with low 'tar' and nicotine levels." [JD-000742]

At the Banbury conference in 1979, the merits of general reduction were discussed by many of the participants. Notably, Dr. Gori, at page 355 of the Banbury report, wrote: "Additionally, if one recognizes the genuine difficulties in selectively removing specific smoke components, it is not surprising that the most practical solution is to reduce total smoke emission and therefore all smoke components, and then to return to specific components that are considered harmless and would restore desirable characteristics of acceptability." [JD-000659]

In 1983, the Third Report of the Independent Scientific Committee on Smoking and Health, stated at page 11, that "Cigarette manufacture has been undergoing a period of rapid

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change. We are encouraged by the decrease in tar yields over the last few years and recommend a continued reduction." [JD-000657]

In 1988, the Fourth Report of the Independent Scientific Committee on Smoking and Health, stated at page 17, that "We conclude therefore that smoking lower tar cigarettes confers a reduced risk of lung cancer than does the smoking of cigarettes with the relatively high yields that were customary 25 or more years ago. Direct epidemiological evidence and the secular changes in smoking habits and lung cancer rates are consistent. While there is uncertainty over the magnitude of the benefit some studies have shown that reductions in the risk of lung cancer from 20 to 40% may arise as a result of reductions in tar yield of about 50%." [JD-000656]

In 1996, Dr. Jonathan Samet, in NCI Monograph 7, at page 80, reported "Wynder and colleagues at the American Health Foundation have conducted an on-going case-control study of smoking and lung cancer that provides information on cigarette type and lung cancer risk over decades since the 1950's. Reports from this study have consistently shown that smokers of lower tar products, indexed in a variety of ways, have reduced lung cancer risk." [JE-045979]

Certainly, over the years there have been many similar endorsements of the general reduction approach by others, including the U.S. Surgeon General. This is just a sample of some of those statements.

Q. How did those views affect cigarette design at Reynolds?

A. It showed us that other people believed that general reduction of tar was a very important direction to take in cigarette design to try to reduce the risks of smoking. It certainly encouraged our efforts to pursue general reduction and that is what we've done for more than 50 years. Even up to my retirement last month, Reynolds continued to work on

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general reduction trying, for example, to improve the consumer acceptability of the very, very low tar cigarettes.

Q. Are you aware of recent criticisms of Reynolds and the other cigarette manufacturers' efforts to lower tar and nicotine since the 1950s?

A. Yes, in recent years, some members of the scientific and public health community have changed their view and have concluded that lower tar cigarettes do not offer any health benefit.

Q. In particular, are you aware of the NCI's Monograph 13 that was published in 2001?

A. Yes.

Q. Was that a change of position?

A. Yes, to me it was a dramatic shift. Up until the publication of that Monograph, there was a consistent view that lower tar cigarettes were better from a health perspective. Now, there is a split of views within the public health community, which further complicates the task of approaching risk reduction through cigarette design.

Q. I will ask you more about those changed positions and new criticisms later in the examination, but let me continue with the efforts in general reduction. The statements you have quoted mostly reference and focus on tar reduction, not nicotine. Why was the focus of the public health community on reducing tar?

A. Because it is widely believed that the health risks of smoking are attributed to the components of tar, not nicotine.

Q. Where did Reynolds focus its efforts?

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A. Our focus was on tar reduction as well. We knew of course that techniques that reduced tar would also reduce nicotine. But, from a design objective standpoint, our goal was to reduce tar, and nicotine followed tar.

Q. Drs. Farone and Wigand testified that cigarette design manufacturers design for nicotine [Farone written direct, 3:12-22; Wigand written direct, 104:6-107:15]; is that true in your experience?

A. No. With general reduction, our objective was on reducing tar. We did not have nicotine objectives or specifications, although we certainly understood that reducing tar would also reduce nicotine.

To avoid any misunderstanding, however, one approach to making safer cigarettes that we have not yet discussed in this examination relates to altering the tar to nicotine ratio. We've researched those cigarettes in the laboratory, and, in connection with that work, we had nicotine design objectives and specifications. None of those cigarettes were ever commercialized, however.

A. GENERAL REDUCTION TECHNIQUES OVERVIEW

Q. I will ask you about the work to alter the tar to nicotine ratio later in the examination. Let's now turn to what has actually been accomplished in the area of general reduction. Have you developed a chart that will help you explain the major general reduction techniques examined by Reynolds and the other cigarette manufacturers since the 1950s?

A. Yes.

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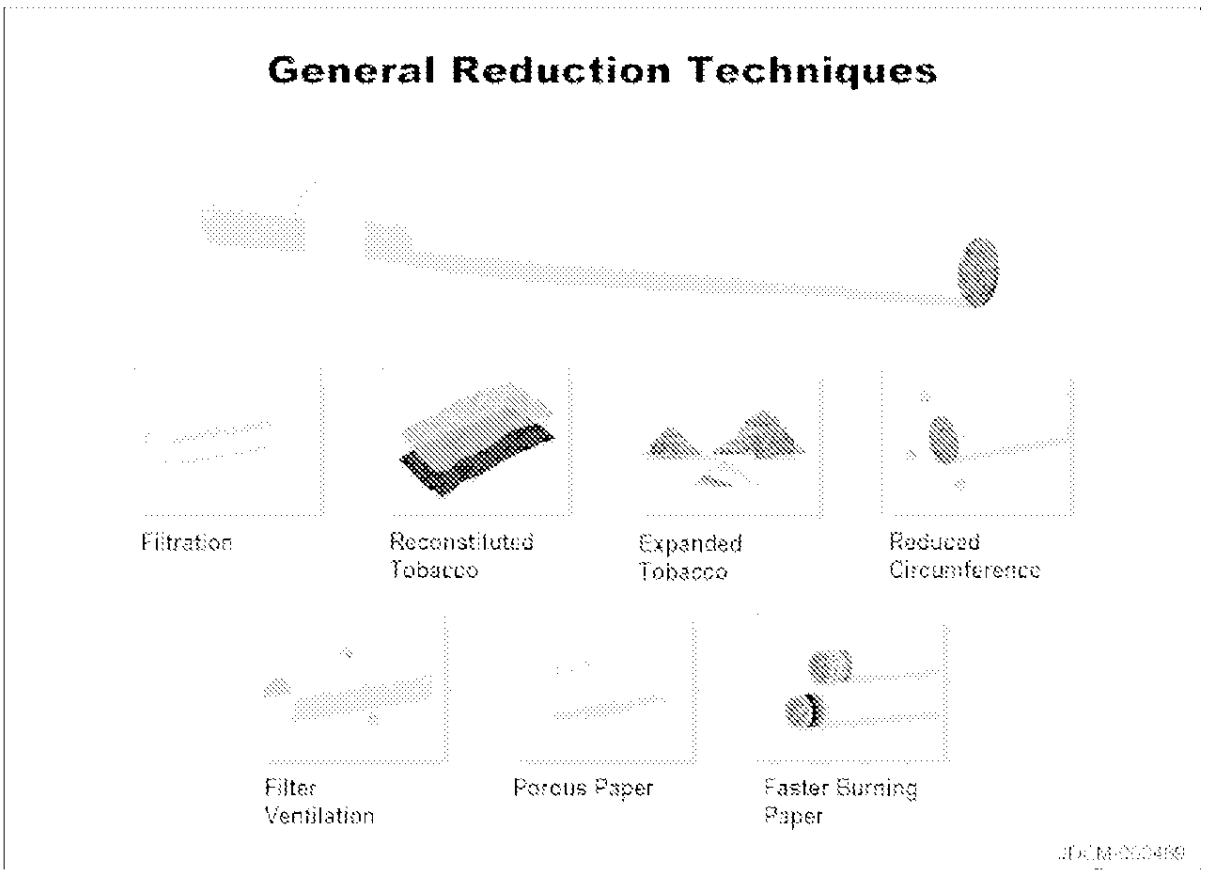

Q. Please explain briefly the various general reduction techniques, with reference to your chart.

A. This chart shows the major approaches to general reduction for the purpose of reducing risks. The approaches include the use of filters and more efficient filters; the use of a processed tobacco called reconstituted tobacco; the use of a processed tobacco called expanded tobacco; reducing the circumference of the cigarette which essentially results in burning less tobacco, so less tar and fewer compounds are generated; the use of filter ventilation, sometimes called air dilution, that reduces the tar yields and the gas phase yields; the use of porous cigarette papers which is actually a form of air dilution that allows air to come in through the cigarette paper and dilute the smoke, so there is less smoke generated at

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the fire cone end; and, the last approach listed here is the use of faster burning papers which essentially reduces the number of puffs and thereby reduces the total yield of tar and all the constituents in smoke.

Q. Have Reynolds and the other cigarette manufacturers used each of these techniques in the cigarettes that they sell commercially?

A. Yes.

Q. Dr. Townsend, was each of these techniques successful in bringing about a general reduction of the yields of compounds found in cigarette smoke?

A. Yes, some techniques are more important than others, and some work synergistically. Filtration, expanded tobacco, and filter ventilation are the three most important ones in terms of general reduction. They have the biggest effect. But, the others are important tools as well.

B. FILTRATION

Q. Let's start with filtration. How do cigarette filters work?

A. The mechanisms of filtration are actually very complicated. A cigarette filter consists of a bundle of fibers that are extremely small. As one draws smoke through the filter, the fibers trap or capture the small liquid smoke particles that I talked about earlier.

Q. Do you have a chart that will help you explain more fully exactly how that works?

A. Yes.

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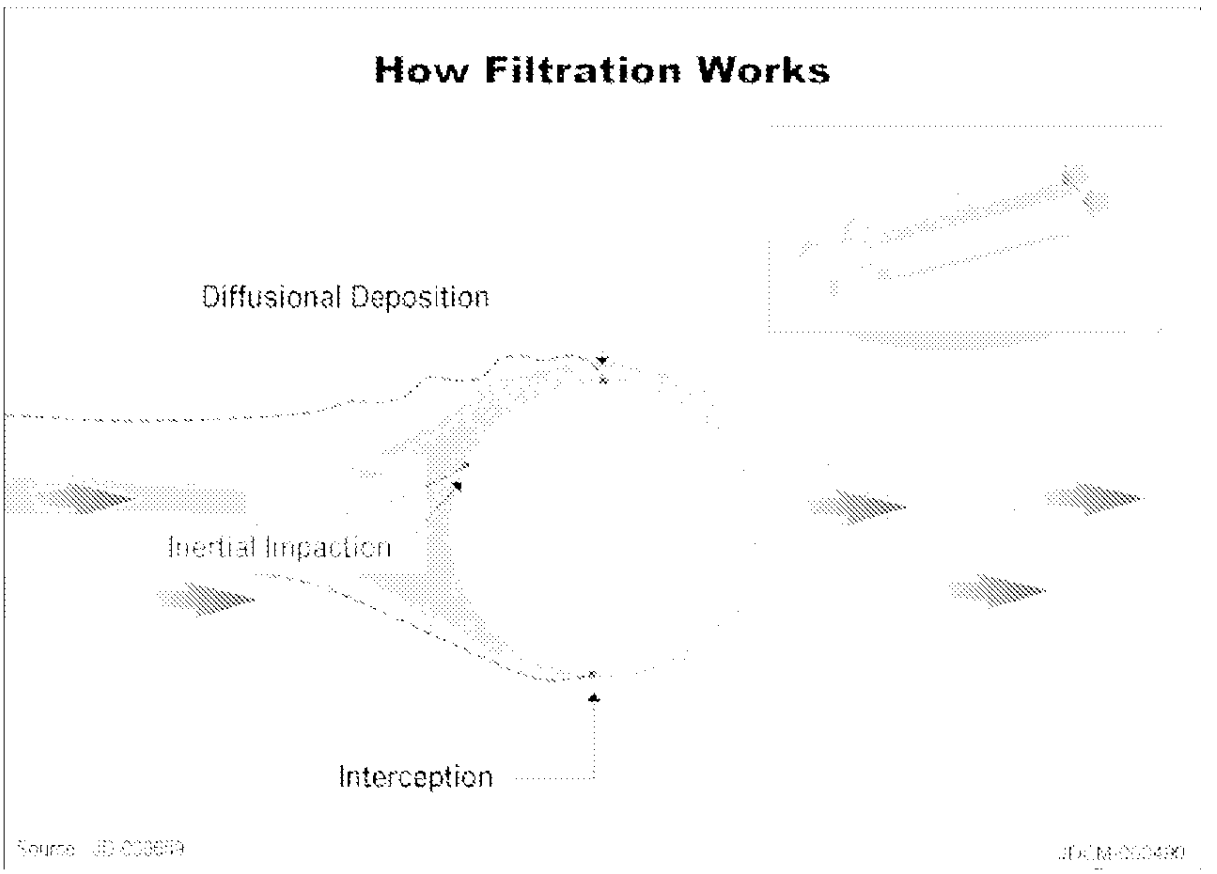

Q. Please explain how filtration works.

A. First of all, the physics of particle capture in a filter is fairly complex, and the mathematics that go with it are also complex. This chart is a simplified representation of what occurs.

The round circle represents a cross-section of a single filter fiber. As the smoke travels through the filter, particles can be trapped by one of three mechanisms.

The first mechanism is inertial impaction. A liquid particle follows the smoke stream and, because of its momentum, it breaks away and collides with the front edge of the fiber. Higher flow rates increase the removal efficiency of particles by this mechanism.

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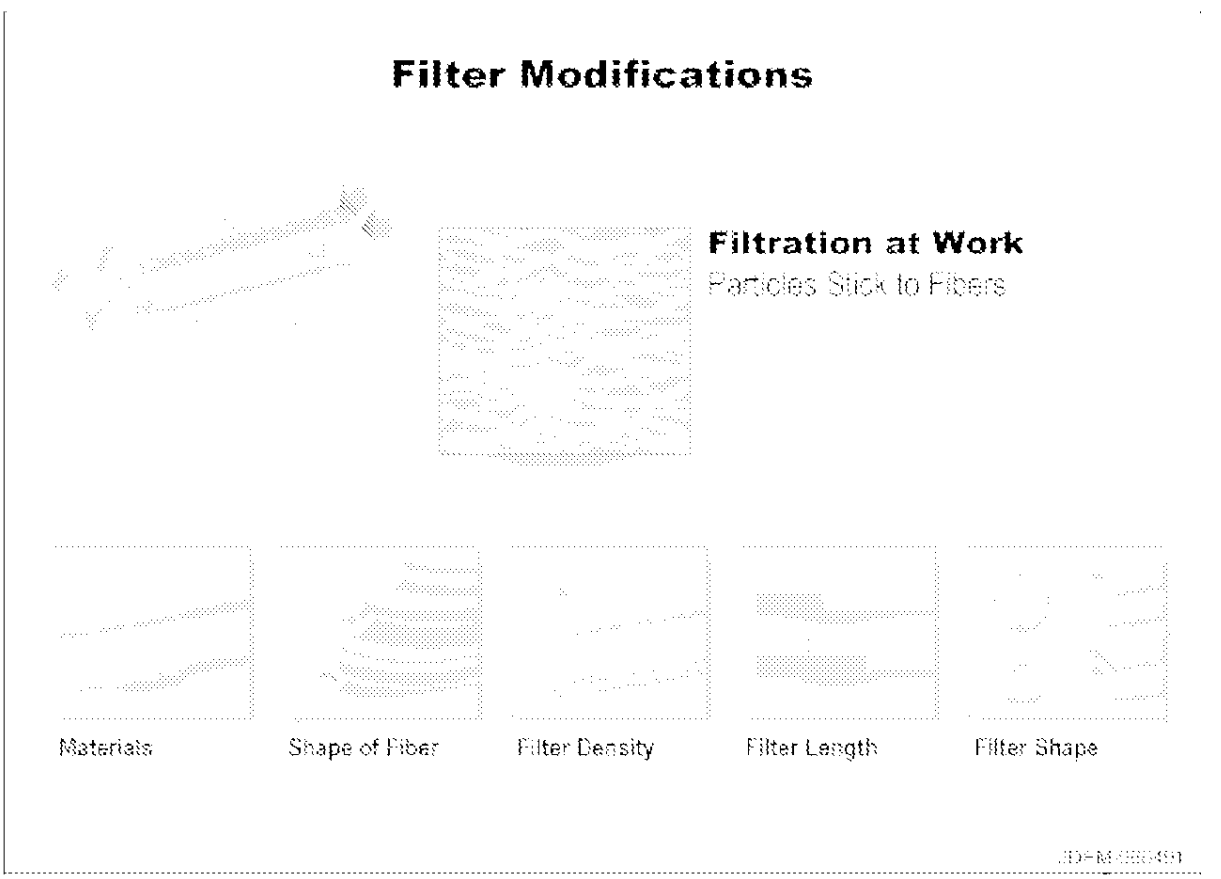
The second mechanism is called interception. In that, the liquid droplet follows the streamline around the fiber. If the streamline is very close to the fiber, the particle may touch it and be captured. The removal efficiency by this mechanism is not dependent on flow rate.

The third mechanism is called diffusional deposition. In that, the particle is moving along a streamline away from the fiber, but due to Brownian diffusion, there is a finite probability that the particle can sidestep the streamline and collide with the fiber. Higher flow rates decrease the removal efficiency of particles by this mechanism.

Q. Have you also prepared a chart about the different filter designs that Reynolds has investigated?

A. Yes, I did.



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Q. Please describe the different filter designs that Reynolds has researched.

A. This chart shows some of the filter modifications that have been researched through the years. The first modification addresses different types of materials: Cellulose acetate is the most common material that's used as a fiber in cigarette filters; but paper, folded paper webs, polypropylene webs, polypropylene fibers and a whole host of different types of materials have also been used.

The shape of the fiber is also very important to filtration. On the previous chart, I showed a cross-section of a round filter fiber. We don't use round filter fibers; rather, we use fibers that are made with specific cross-sectional shapes like a Y shape or an I-beam shape. The reason we do that is because that increases the surface area of the fiber and will increase the removal efficiency or the trapping efficiency of the particles.

Increasing the fiber density inside the filter is a very important modification. Obviously, if you increase the density, you're packing more fibers inside that filter and with more fibers, more smoke particles are removed.

Increased filter length is an important modification. Longer filters remove more particles.

And lastly, specialized filter shapes sometimes can alter the filtration efficiency as well.

Q. How long has Reynolds been doing this research and development on different types of filters?

A. Since the 1950s. We marketed the first highly successful filtered cigarette in 1954 and that was Winston.

Q. Is there any limit, from a technical perspective, to the amount of tar that you could catch with these filters?

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A. No, technically there's no limit. One can design filters that have 99.9-plus percent removal efficiency. But if you do that, the cigarette will have a very high pressure drop and will not be consumer acceptable.

C. RECONSTITUTED TOBACCO

Q. Another general reduction technique you mentioned was the use of reconstituted tobacco. What is reconstituted tobacco?

A. In the processing of tobacco, pieces of tobacco that are too small to be used in cigarette manufacture are generated. Reconstituted tobacco was a process invented by Reynolds back in the late 1940s so that we could collect the small pieces, put them together and turn them into larger pieces that we could then add to our tobacco blends. We ultimately determined that reconstituted tobacco sheet also offered a general reduction in tar and nicotine, even though that was not the original purpose of it.

Q. Do you have a chart that shows how Reynolds makes reconstituted tobacco?

A. Yes.

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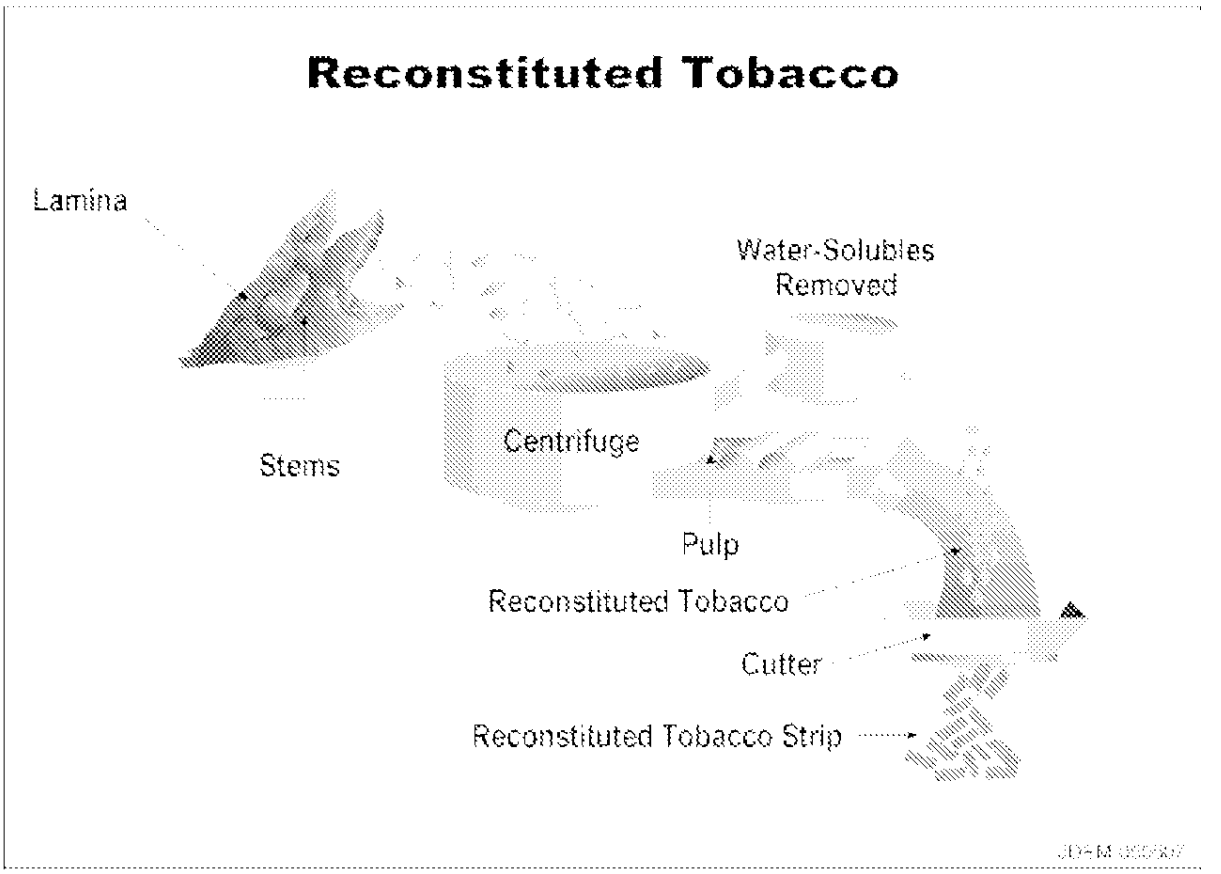

Q. Please explain the reconstituted tobacco sheet process.

A. In manufacturing reconstituted tobacco one uses small pieces of lamina, some tobacco dust that is generated during the stemming process, and stems from the tobacco plant. All that goes into a centrifuge and water is added. The water extracts materials from the tobacco, including nicotine and flavorful compounds, and then those materials are separated from the pulp. The resulting tobacco pulp, which is mainly cellulose, pectin and lignin, is then made into a paper sheet using normal papermaking technology. We take the paper sheet of that pulp and the water soluble materials are reapplied. The sheet is dried and then goes into a cutter, where it's cut into pieces that are the right size for cigarette manufacturing.

Q. Why are the water solubles taken out and then reapplied?

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A. The papermaking process involves a lot of water. If we didn't take the water solubles out first, when we made the paper sheet, the water would wash out the soluble materials, which include all those flavorful compounds, sugars and nicotine.

Q. What would happen to the resulting tobacco sheet if all the water solubles were washed away?

A. Without the water solubles being reapplied, the reconstituted tobacco sheet would not burn like tobacco or taste like tobacco. It would be like smoking a sheet of brown paper.

Q. How does reconstituted tobacco sheet compare with tobacco leaf with respect to tar and nicotine yields?

A. The use of reconstituted tobacco lowers tar and nicotine yields in large part because of the tobacco stems that are used in making it. As compared to tobacco leaf, tobacco stems generate less tar and nicotine when burned. The nicotine yield is reduced because stems naturally contain less nicotine and, in addition, the reconstitution process itself causes a loss of nicotine.

Q. How long has Reynolds been using reconstituted tobacco in its cigarettes?

A. We invented the process in the late 1940s and we used it commercially in 1954 when we introduced our Winston cigarette.

Q. In addition to reducing tar and nicotine, does reconstituted tobacco have any effect on the biological activity of the tobacco smoke?

A. Yes, it does. In fact, after we invented the process, we found – as did the government through the National Cancer Institute-Tobacco Working Group studies – that the tar from burning reconstituted tobacco had lower biological activity on an equal weight of tar basis. Specifically, it showed less tumorigenicity in the mouse skin painting assay.

Q. Was Reynolds' use of reconstituted tobacco a secret?

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A. No, Reynolds' use of reconstituted tobacco was actually mentioned in *Reader's Digest* in July 1957. In addition, in testimony before Congress, Bowman Gray, Reynolds' CEO, discussed the use of reconstituted tobacco.

Q. What percentage of reconstituted tobacco is used by Reynolds in its tobacco blends?

A. Typically commercial blends contain about 10 percent reconstituted tobacco; however, it can go as high as about 25 percent.

Q. Why doesn't Reynolds use more reconstituted tobacco in its cigarettes?

A. At high levels, the reconstituted tobacco changes the taste characteristics of the cigarette. Empirically, we found that we can go easily up to, say, 15 to 20 percent without any real taste issues. Beyond that, we run into consumer acceptability issues due to the taste deficiencies of reconstituted tobacco compared to regular tobacco leaf.

D. LESS TOBACCO: THE REDUCTION OF TOBACCO IN THE ROD AND THE USE OF EXPANDED TOBACCO

Q. Let's move on. Dr. Burns testified that although you would expect that, when compared to high tar cigarettes, low tar cigarettes would start out with less tobacco and nicotine in the tobacco rod, they do not [Burns written direct, 45:5-8]. Now, do today's low-tar cigarettes contain as much tobacco and nicotine in the tobacco rod as higher tar cigarettes from the 1950s?

A. No, Reynolds reduced the amount of tobacco and nicotine in its cigarettes.

Q. What is the effect of using less tobacco on tar and nicotine yields?

A. By burning less tobacco, less tar and nicotine is generated.

Q. How does Reynolds reduce the amount of tobacco in its cigarettes?

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A. We generally do three things. The two ways that are easiest to think about are reducing the circumference of the cigarette and shortening the tobacco rod. The third way is through the use of expanded tobacco.

Q. Since the 1950s, has Reynolds reduced the circumference of its cigarettes and shortened the tobacco rod?

A. Yes.

Q. You mentioned expanded tobacco. Who invented expanded tobacco?

A. Dr. Jim Frederickson of Reynolds.

Q. When?

A. Back in the mid-1960s. The technology was patented in the 1970s.

Q. What is expanded tobacco?

A. The process that we originally invented used Freon as an impregnate. What you do is actually put the tobacco in Freon, apply very high pressure and then quickly release the pressure. When you do that, the Freon escapes from the tobacco very quickly and actually blows the tobacco apart, much like what happens with popcorn.

Q. Does Reynolds' expansion process simply return the tobacco back to its original size?

A. No, our expansion process makes the tobacco larger than its original size.

Q. Does Reynolds still use Freon to expand tobacco?

A. No, because of the environmental concerns with Freon, we now use a process employing carbon dioxide.

Q. What effect do these three techniques that you mentioned have on tar and nicotine yields?

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A. All three of the techniques I mentioned before reduce tar and nicotine yields. Expanded tobacco, however, has been most successful of the three. In fact, expanded tobacco is one of the major cigarette design tools, along with filtration and air dilution, for reducing tar and nicotine.

Q. When did Reynolds start putting expanded tobacco in commercial cigarettes?

A. The first commercial use was in about 1970.

Q. Do your competitors use expanded tobacco in their cigarettes?

A. Yes, they do.

Q. Is there any limit to the amount of expanded tobacco that could be used in cigarettes?

A. Technically, there is no limit on the amount of expanded tobacco you can use.

Q. So then why doesn't Reynolds use 100% expanded tobacco in all of its cigarettes?

A. For the same reasons we do not use more reconstituted tobacco sheet: taste. We've tried making cigarettes out of all expanded tobacco, and they have very limited consumer acceptance. The taste is just too deficient.

Q. You testified about consumer acceptability earlier with regards to the design objectives in making a new product. What does "not consumer acceptable" mean with regards to Reynolds' cigarette products?

A. Clearly, it means that the taste characteristics or other product attributes are so different that consumers will not buy those products. They don't like them.

Q. Do you have personal knowledge of the types of cigarettes that smokers find acceptable?

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A. Yes, through either the consumer testing procedures that we do in-house, or through experience in the marketplace.

Q. What types of consumer testing does the Reynolds R&D Department do?

A. There are several different types of consumer testing of prototypes or products that we conduct. We can have internal expert panel evaluations, but more often, we have outside, non-employees come in and participate in smoking panels where they judge the smoking qualities. Additionally, we do large-scale mail-out studies to hundreds of people where we send them two packs of a prototype product and ask for their evaluation and comments not only on the smoking attributes, but on its acceptability, and their likelihood that they would purchase such a product.

Q. You mentioned that you also look at the experience in the marketplace. What did you mean by that?

A. Marketplace performance is the ultimate test of consumer acceptability because that is what happens in the real world with smokers. If smokers don't like a cigarette, regardless of any benefits that it may have, it will not sell. As I mentioned, that's exactly what happened when we and our competitors tried to sell a 100% expanded tobacco cigarette.

Q. To what extent does Reynolds use expanded tobacco in the cigarettes it sells today?

A. Virtually all of our products contain some expanded tobacco. The very low-tar cigarettes have more and in those cigarettes, it can approach 50 percent. For our lights products, we typically use 20 to 25% expanded tobacco.

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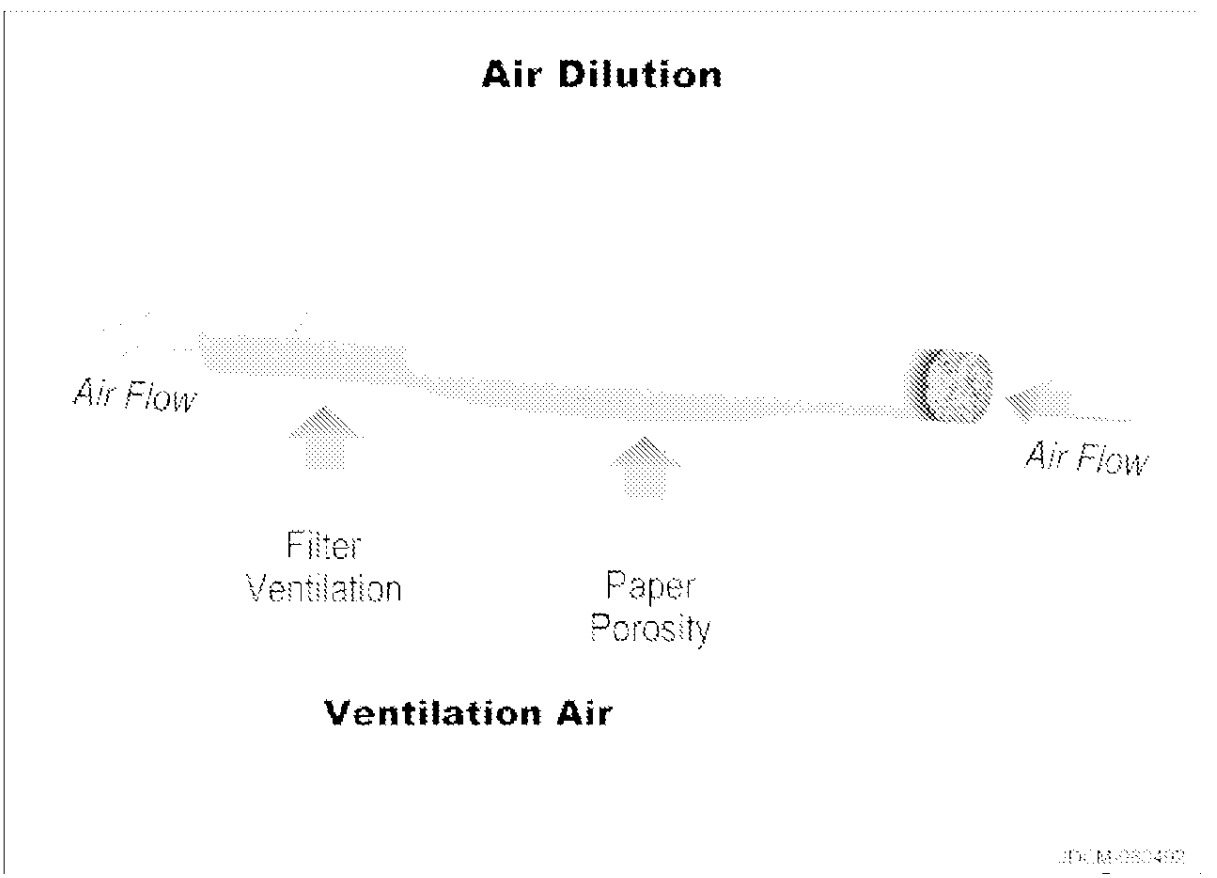
E. AIR DILUTION: FILTER VENTILATION AND MORE POROUS CIGARETTE PAPER

Q. Another general reduction technique you referred to was air dilution. What is air dilution?

A. Air dilution is another one of the very important tar reduction techniques that we have used. The goal of air dilution is to dilute the smoke generated by smoking with fresh air.

Q. Have you prepared a chart that will assist you in explaining air dilution?

A. Yes.



Q. How is air dilution accomplished in cigarettes?

A. Air dilution can occur at two different locations in a cigarette. It can occur at the filter, if perforations or vent holes are placed in the filter. When the smoker or a smoking

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machine draws on the cigarette, air is drawn from the outside through those perforations and it mixes with the smoke to dilute it. Thus, a portion of what goes into the smoker's mouth is, in fact, air mixed with that lesser amount of smoke. This form of air dilution is sometimes called filter ventilation.

Paper porosity is the second form of air dilution. With this technique, the cigarette paper wrapping the tobacco rod can be made very porous in which case fresh air enters the tobacco rod during puffing. As with filter ventilation, by injecting fresh air, the smoke is diluted.

One additional consequence of air dilution is that, when a puff is taken, less tobacco is actually burned because there is less air drawn through the front end of the tobacco column to fuel the combustion process. As I previously testified, burning less tobacco reduces tar and nicotine yields.

Q. Was Reynolds the first company to experiment with air diluted filters?

A. No. Some of our competitors developed air-diluted filters in the very late 1950s and early 1960s, and introduced that innovation at that time. Reynolds studied the technology, learned to apply it to commercial products, and also put it in the market. But, we were not the first company to do so.

Q. When did Reynolds start using filter ventilation in commercial cigarettes?

A. By the late 1960s. One of our first brands to use filter ventilation was Tempo, our charcoal filtered cigarette that I referred to earlier.

Q. And is the use of filter ventilation a secret?

A. No, it's not a secret at all. In fact, when it was introduced there were articles in the popular press including *Reader's Digest* and *Consumer Reports* that discussed air dilution.

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In addition, some of our competitors noted the existence of filter ventilation in some of their advertisements in the early 1960s.

Q. Let me show you JD-000748. Please identify it for the Court.

A. This is a November 1959 *Reader's Digest* article entitled "The Search for 'Safer' Cigarettes."

Q. What does this article report about ventilation?

A. Beginning on page 39 under the section entitled "Beyond Filtration," the authors note that ventilating cigarettes is an old idea and then they refer to a patent from 1890 about perforating cigarette paper. They go on to report that "[o]nly last February a scientist wrote to the *British Medical Journal* that one way of 'reducing considerably the total tar inhaled is to provide ventilation near the stub in the form of small holes or a band of more porous paper.'" The authors then go on to discuss the use of more porous paper in addition to ventilation in a section entitled "Air Conditioned Smoke."

Q. Earlier you mentioned consumer acceptance problems with very high efficiency filters. What effect, if any, does the use of filter ventilation have on the pressure drop, or difficulty of puffing, high efficiency filters?

A. Filter ventilation changes the air flow patterns within the cigarette. More air enters through these vents and less air will come down the tobacco column. So that will result in an overall reduction in how hard it is to draw through the cigarette. Placing filter vents in those very efficient filters can make them more consumer acceptable by reducing the level of work that's required to draw on the cigarette.

In addition, filter ventilation acts synergistically with filter efficiency. If one uses an efficient filter and the vents are placed in the appropriate location, the smoke that's moving down through from the tobacco column and into the front section of the filter is moving

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slower. And because it's moving slower, it can be trapped by the fibers far more efficiently through diffusional deposition. Thus, the section of the filter nearest the tobacco rod becomes much more efficient by virtue of the vent holes.

Q. In addition to the general reduction of all constituents, what effect, if any, does filter ventilation and paper porosity have on particular smoke constituents?

A. Air dilution reduces all constituents, but it affects CO and NO_X more than you would expect just based on the air dilution level. CO, NO_X , and other light gases, because they're small molecules and the smoke is moving slower down through the tobacco column, are more likely to diffuse out of the tobacco column. And, by diffusion, I mean those light gases will escape into the air and will not be in the mainstream smoke. So, air dilution provides some additional benefits on top of general reduction.

Q. To what extent does Reynolds use filter ventilation in its cigarettes?

A. Many, but not all, of our brands employ filter ventilation. The amount of filter ventilation we use ranges from 0 to 80% in our brands.

Q. Why doesn't Reynolds use 100% filter ventilation?

A. By definition, a 100% ventilated product would mean that all of the air from a puff would come from the outside air and none would enter through the fire cone. Therefore, there would be no smoke. Smokers would not accept a cigarette if all they got was air and no smoke. Even cigarettes with very high levels of filter ventilation, but still less than 100%, are not very consumer acceptable because there is virtually no smoke. Those cigarettes are also hard to light.

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F. GENERAL REDUCTION AND COMMERCIAL CIGARETTES – WINSTON

Q. I now want to talk about the effects over the years of the general reduction techniques that you've just discussed on Reynolds' cigarettes. And let's take Winston as an example. When was Winston introduced on the market?

A. 1954.

Q. And since 1954, has Reynolds used these general reduction methods on Winston?

A. Yes. We've not only used them, but we've improved them and modified them over the years.

Q. And is the Winston of 1954 different or the same as a Winston of today?

A. They're very different products.

Q. Have you prepared a chart that shows the effect of the design changes on the tar and nicotine yields of Winston?

A. Yes, I have.

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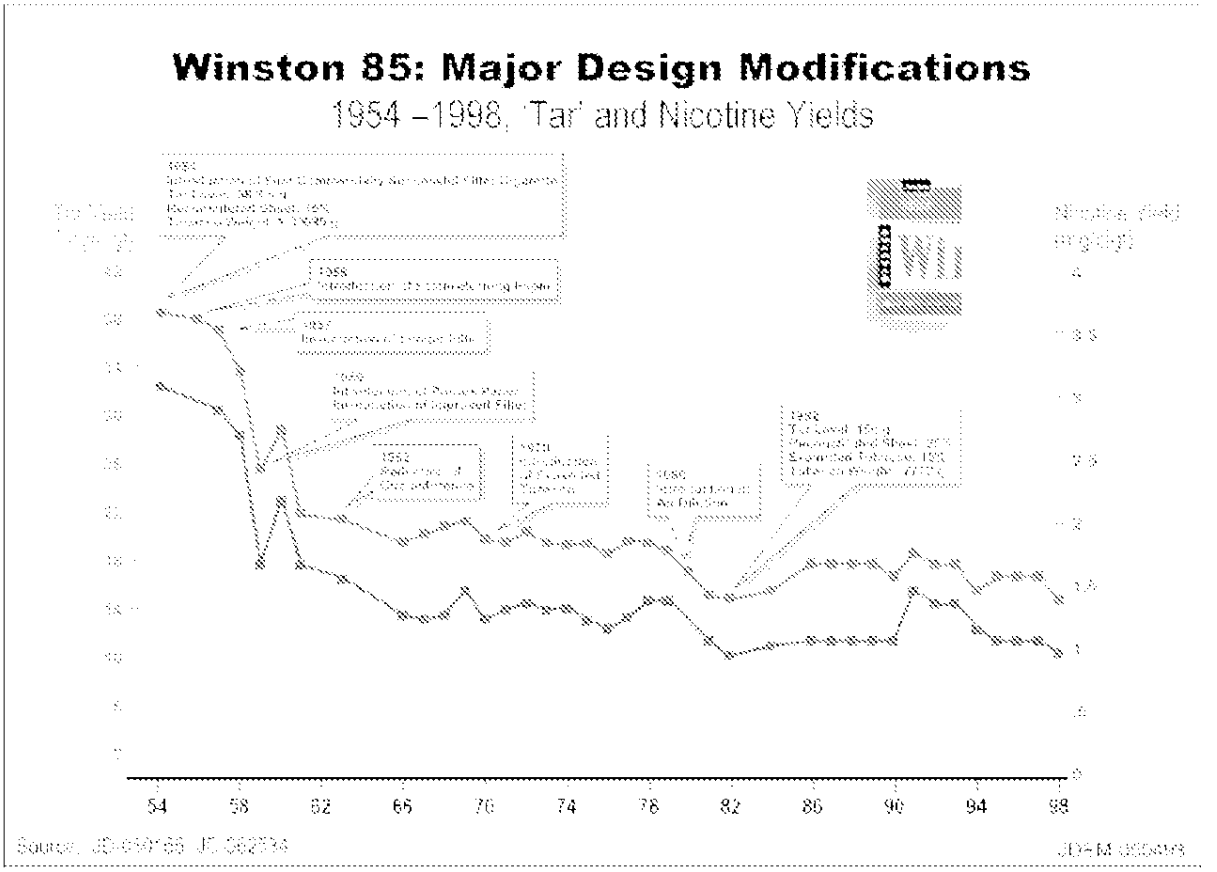

Q. What does this chart show about the effect of general reduction on Winston?

A. This chart reflects the tar and nicotine yields of our full-flavor Winston from 1954 to 1998. On the left-hand side is the scale for tar yield per cigarette measured in milligrams. The amount of tar per cigarette over time is represented by the blue line. On the right-hand side is the axis for nicotine yield, also measured in milligrams. And that value over time is represented by the red line on the chart.

In 1954, when Winston was introduced, its tar yield was about 38 milligrams per cigarette. So it was very high. By 1956, we started figuring out ways to improve the filter, to make it more efficient and you can see a pretty rapid drop in tar yield. We introduced longer filters during that period of time and introduced more porous cigarette papers to help dilute the smoke. In 1963, we reduced the circumference of the cigarette, so that less tobacco

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was burned. In 1970, we built on that by adding expanded tobacco, again to burn less tobacco. We introduced air dilution in 1980. And you'll see that the tar level for Winston has gone from 38 milligrams down to about 15 in 1998. Today the tar level remains around 15 milligrams per cigarette. The nicotine has pretty much paralleled the tar reduction.

The reduction in nicotine is not exactly the same as the tar reduction, but it is very close. Specifically, the nicotine yield for Winston has gone from about 3 milligrams in 1954 down to about 1 milligram today. The reason the tar and nicotine reductions are not identical is because some of these different general reduction techniques have a slightly different effect on tar than they do on nicotine.

Q. Does Reynolds intend for some general reduction techniques to have a different effect on nicotine versus tar?

A. No, it is just part of the complex science of what is going on inside a burning cigarette.

Q. Why is there a different effect on tar and nicotine for some general reduction techniques?

A. Some techniques are more efficient at reducing tar than they are for nicotine, and that is a function of the complex interactions of smoke with filtration and air dilution. It is not an effect that we intend.

Q. In discussing Reynolds' attempts at selective reduction, the constituents that were mentioned included BaP, phenols, ciliastats, nitrosamines, CO, NO_X, metals and radioisotopes. What effect has general reduction had on the yields of those smoke constituents?

A. General reduction reduces all of those constituents.

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Q. How does today's Winston compare to the 1954 Winston in terms of the smoke yields of those compounds?

A. Today's Winston has significantly reduced smoke yields compared to 1954.

Q. Do all of Reynolds' commercial cigarettes have a filter?

A. No, we make a version of Camel without a filter.

Q. Fifty years after pioneering the use of the filter, why would Reynolds continue selling a cigarette that doesn't even have a filter?

A. Consumer demand. There are a number of smokers that want that product, so we continue to sell it. We want to compete in every segment of the market.

Q. Can you reduce tar and nicotine yields even in a cigarette that doesn't have a filter?

A. Yes, you can.

Q. Has Reynolds done so with the Camel?

A. Yes, we have.

Q. Can you describe what the reduction in tar and nicotine has been for Camel since the 1950s and how you've been able to do that?

A. Yes. Even without a filter, because of the other design tools, like the use of higher levels of expanded tobacco, more porous cigarette papers, reconstituted tobacco sheet, and a few other techniques taken together, we have reduced the tar yield of Camel nonfilter from about 38 milligrams of tar in the 1950s down to about 25 milligrams today. Similarly, the nicotine yield has gone down from about 3.4 milligrams in the 1950s to about 1.7 milligrams today, so about a 50% reduction. All of this was accomplished without the use of a filter.

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G. GENERAL REDUCTION AND THE DECLINE OF SALES-WEIGHTED AVERAGE YIELDS

Q. Dr. Townsend, have the other cigarette manufacturers in the United States also used general reduction techniques that we've been talking about?

A. Yes. The other manufacturers have used general reduction techniques in much the same way that Reynolds has. And they've also seen a comparable reduction in tar and nicotine yields.

Q. As a result of all the cigarette manufacturers using general reduction, has there been any effect on the sales-weighted average tar and nicotine yields for cigarettes over the past 50 years?

A. Yes.

Q. Have you prepared a chart that will help explain your testimony regarding the effect of general reduction on tar and nicotine yields over time?

A. Yes.

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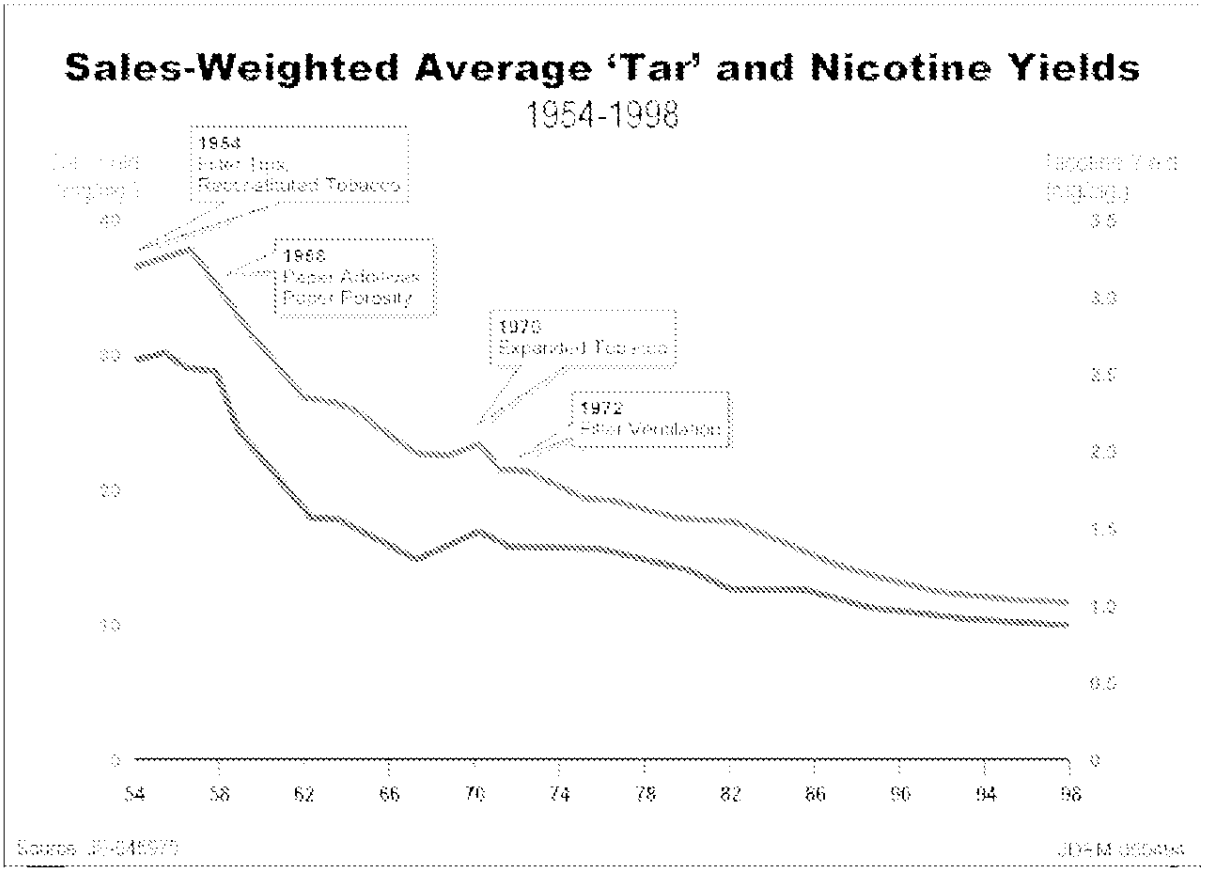

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2 Q. Using your chart, please explain what the effect has been.

3 A. On my chart, the blue line represents the sales-weighted average tar yield and the red
4 line represents the sales-weighted average nicotine yield. The vertical axis on the left is the
5 scale for tar yield; the vertical axis on the right is the scale for nicotine yield. As this chart
6 shows, there's been a major reduction in sales-weighted average tar and nicotine yields in the
7 U.S. The sales-weighted average tar yield has declined from about 38 mg in the early 1950s
8 down to about 12 mg in 1998. Similarly, the sales-weighted nicotine yield has declined from
9 about 2.7-2.8 mg, down to about 0.9 today.

10 Q. To be clear, what does the phrase "sales-weighted average" mean?

11 A. Sales-weighted average refers to the yield of the average product sold in the United
12 States at any point in time. For example, to calculate it for tar, you take the tar yield of each

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cigarette in the market, multiply by its share of market, add all of those figures together, and then divide by the total number of cigarettes in the market. The sale-weighted average nicotine yield is calculated in the same way. The Federal Trade Commission reports on tar and nicotine include the sales-weighted average smoke yields going back to 1967.

Q. Was it technology alone that caused the dramatic decrease in tar and nicotine since the 1950s?

A. No, it wasn't the design alone. We at Reynolds can – and my competitors can – design cigarettes with lower and lower tar and nicotine yields, but it also requires consumers to like those products and buy them. So I would say that it's cigarette design and consumer acceptance together that has caused the dramatic decrease in tar and nicotine.

Q. Did there come a time when the steep decline in sales-weighted average leveled off?

A. Yes, as the sales-weighted average chart shows, from about 1980 forward, there's been very little continued reduction in tar and nicotine. That's because smokers have really not continued to move to lower and lower tar yields. Because the taste trade-offs are so great, a five milligram ultra light cigarette is not very popular in the marketplace; and very few smokers will buy a one milligram product. The lights category, like Winston Light, Camel Light, and Marlboro Light, represents the largest category in the U.S. market today, and their yields are close to the sales-weighted averages. So there has been a major reduction, but smokers are not continuing to trade down, largely because of the very light taste characteristics of those even lower tar products.

Q. Were lower tar and nicotine cigarettes still available for smokers to choose?

A. Yes, and the lower tar and nicotine products were available even before we see this leveling off. So they were available in the marketplace, but smokers weren't continuing to

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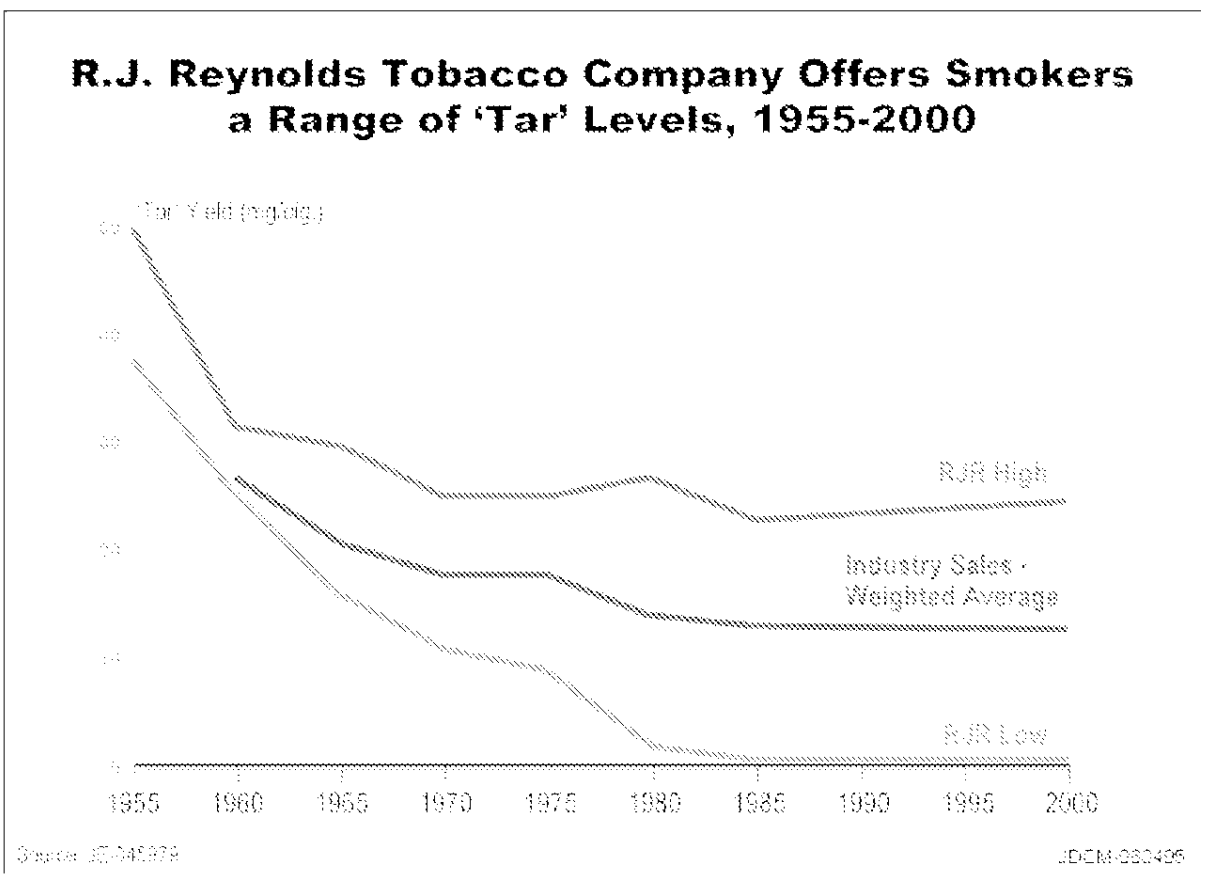
move down in great numbers, although some switched. Some people preferred the very low tar products, but overall in the marketplace now, most smokers are not continuing to trade down.

Q. And have you prepared a chart that shows the range of products that have been available from Reynolds since the 1950s to consumers?

A. Yes, I have.



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Q. What does this chart show?

A. What this shows is the range of products that Reynolds has manufactured and sold from 1955 to the year 2000. And the blue line represents the highest tar product we made; the red line represents the lowest tar product we made for any given year. So you'll notice in 1955, the highest tar product was 50 milligrams; the lowest tar product we made was about 38 milligrams. Compare that to 2000, where the highest tar product we made is about 25 milligrams per cigarette, and the lowest tar cigarette is almost zero. It's so low that it's very difficult to measure. Now, an important point here, is that the highest tar product we make today is significantly lower than the lowest tar product that we used to make.

In the center of this chart, I've overlaid the industry sales-weighted average tar, which is the same curve as from the previous chart. And, in returning to one of the earlier questions, what this graph shows is that at least since the early 1960s, Reynolds has offered cigarettes to consumers that yielded less tar and nicotine than the industry sales-weighted average. As I testified, most smokers, however, chose not to trade down further despite the availability of those products.

Q. Why has Reynolds offered cigarettes in such a wide range of tar yields?

A. We offer that range because smokers prefer different products. There are millions of smokers in the United States. Some smokers prefer very low tar products, like the one milligram or less that are available. There are some smokers who prefer the higher tar cigarettes, a full flavor cigarette that will be in the 15 or 16 milligram range. There are even still some smokers today who prefer the very high tar unfiltered cigarettes at 25 milligrams. Some people prefer the higher tar cigarettes where there's more taste; some people prefer the very light taste. People just prefer a range and we've offered that range in the commercial market. Again, we want to compete in every part of the market.

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H. NATIONAL CANCER INSTITUTE – TOBACCO WORKING GROUP

Q. Did there ever come a time when the government looked at the general reduction techniques that you've discussed and evaluated their effectiveness?

A. Yes, as part of the National Cancer Institute's Less Hazardous Cigarette program, the Tobacco Working Group ("NCI-TWG") directed research that evaluated general reduction in terms of its effectiveness at constituent reductions and biological activity. The results of these research studies were published in five official government reports. Since then, various public health scientists, including the Surgeon General and Dr. Wynder of the American Health Foundation, have considered that information and discussed it in publications.

Q. What was the NCI-TWG?

A. In 1968, the National Cancer Institute put together a scientific working group to try to figure out how to design less hazardous cigarettes. The whole program was entitled "Toward Less Hazardous Cigarettes." That effort included the scientific panel called the Tobacco Working Group, composed of scientists from the government, from the public health community, from universities and from the tobacco industry. And all the scientists came together, evaluated a number of cigarette design modifications and evaluated what their effects on tar and nicotine yields were. They also looked at some more detailed chemistry and tried to correlate, if they could, the detailed chemistry with some of the results of the biological testing that they conducted.

Q. Did the NCI-TWG issue reports of the research being conducted?

A. Yes, they issued status reports, as well as summary reports of the many cigarette modifications tested.

Q. Let me show you JD-000650, JD-000838, JD-000863, JD-000864, JD-000865, JE-067628, and JD-000844. Please identify these exhibits for the Court.

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A. They are examples of reports from the NCI-TWG research efforts.

Q. Did you prepare a demonstrative exhibit that summarizes the evaluation of the general reduction techniques by the NCI-TWG?

A. Yes.

Reduction of Biological Activity of Cigarette Smoke*

Method	CO	Cilia Toxicity	'Tar'	Nicotine	BaP	Selective Biological Reduction: Carcino-genicity	Selective Biological Reduction: Tumor Promoters	Remarks
Agricultural Aspects								
Tobacco Varieties (Bright-Burley)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
New Tobacco Cultivars	?	+	[illegible]	[illegible]	+	?	?	
Leaf Position	[illegible]	+	[illegible]	+	+	?	?	Lowest stalk position; highest reduction
Selection by NO3	[illegible]	[illegible]	[illegible]	[illegible]	+	[illegible]	?	
Tobacco Processing								
Extraction: Organic Solvents	[illegible]	[illegible]	[illegible]	[illegible]	+	[illegible]	?	Only of academic interest
Cut		[illegible]		[illegible]	[illegible]	[illegible]	?	
Stems	[illegible]	+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Reconstituted Tobacco Sheets (RTS)**	[illegible]	+	[illegible]	[illegible]	+	[illegible]	[illegible]	Some RTS give high CO
Reconstituted Tobacco Sheets (Paper Process)	[illegible]	+	+ [illegible]	[illegible]	+	+ [illegible]	?	
Expanded Tobacco	[illegible]	[illegible] ?	[illegible]	[illegible]	[illegible]	[illegible] ?	[illegible]	
Cigarette Production								
Porosity of Paper	[illegible]	+	[illegible]	[illegible]	+	[illegible]	?	
Perforated Filters	[illegible]	+	+	[illegible]	+	[illegible]	?	
Cellulose Acetate Filter	[illegible]	[illegible]	[illegible]	[illegible]	+	[illegible]	[illegible]	
Charcoal Filter***	[illegible]	[illegible]	[illegible]	+	+	[illegible]	[illegible]	
Additives: NO3	[illegible]		[illegible]	[illegible]	+	[illegible]	[illegible]	Only of academic interest
Tobacco Substitutes	[illegible]	+	[illegible]	[illegible]	+	[illegible]	[illegible]	

* Reductions: + +, 50%; + significant; [illegible] insignificant; ? questionable; [illegible] increase; ? unknown.
** Data given for reconstituted tobacco sheets relate to those not made by the paper process.
*** Reduction of the "nicotine" and BaP are in general greater with cellulose acetate filters than with charcoal filters.
Source: US-64671

JDCM-080496

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Source: https://www.industrydocuments.ucsf.edu/docs/xhgl0001

Q. What is the source for your chart?

A. This particular chart appears in the 1979 Surgeon General's Report, but the information is based on the public reports from the TWG's efforts, as well as Dr. Wynder's research over the years.

Q. Please explain the significance of that chart with respect to the design techniques that we've discussed.

A. This chart compares some of the cigarette design techniques that we've already talked about, and how they affect a cigarette's performance in terms of the yields of compounds such as carbon monoxide, tar, nicotine, and benzo[a]pyrene. It also compares the techniques' effectiveness in terms of certain biological tests like ciliatoxicity, an *in vitro* test, or in mouse skin painting, an *in vivo* test. So, let me go through some of these.

One general reduction technique I previously discussed was reconstituted tobacco. The NCI-TWG found that the use of reconstituted tobacco sheet made by the paper process gave a significant reduction in ciliatoxicity, a greater than 50% reduction in tar, a significant reduction in nicotine, a significant reduction in benzo[a]pyrene, and a greater than 50% reduction in mouse skin painting carcinogenicity on an equal weight of tar basis. The NCI-TWG also found insignificant reductions in carbon monoxide and tumor promotion.

For another example, one can look at expanded tobacco. The NCI-TWG found that the use of expanded tobacco provided a significant reduction in carbon monoxide, a greater than 50% reduction in tar, nicotine and benzo[a]pyrene. The biological activity tests showed questionable reductions in ciliatoxicity and mouse skin painting carcinogenicity, and insignificant reductions in tumor promotion, all on an equal weight of tar basis.

With respect to filtration, the standard cellulose acetate filter that has been in the marketplace since the 1950s provided significant reductions in tar, nicotine and

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benzo[a]pyrene. In addition, the NCI-TWG research found that filter ventilation provided significant reductions in tar, nicotine and benzo[a]pyrene, and a greater than 50% reduction in carbon monoxide. Filter ventilation also provided a significant reduction in ciliatoxicity, with insignificant or unknown effects on carcinogenicity measures, on an equal weight of tar basis.

Q. Let's discuss the NCI-TWG a little further. You mentioned that the cigarette manufacturers were invited to participate in the NCI-TWG. Which manufacturers participated?

A. Reynolds, Philip Morris, Lorillard and Brown & Williamson participated in the TWG.

Q. Who from Reynolds were members of the NCI-TWG?

A. During its ten-year existence, two scientists from Reynolds participated – Dr. Murray Senkus was first and then Dr. Alan Rodgman.

Q. Who from the government and public health community participated in the NCI-TWG?

A. Many prominent scientists participated, including Drs. Ernst Wynder and Dietrich Hoffmann from the American Health Foundation, and Dr. T.C. Tso from the U.S. Department of Agriculture.

Q. You said that the NCI-TWG looked at various alternative cigarette designs. How many different designs for a less hazardous cigarette did they investigate?

A. There were well over a hundred design alternatives that were evaluated. Most of the designs were ideas that came from the cigarette companies' scientists, or they were already being used in the marketplace. The NCI-TWG evaluated the effectiveness of these

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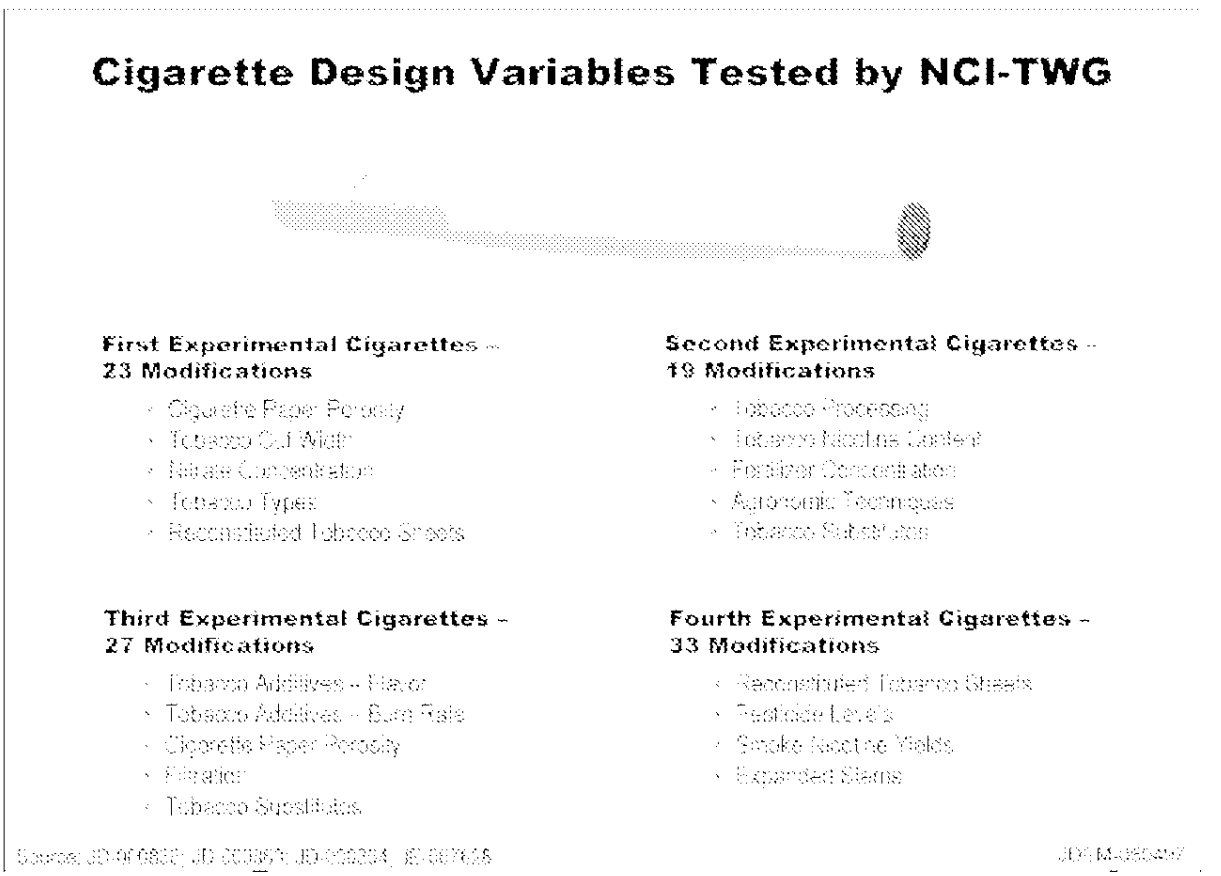
techniques, looked at the chemistry and the biological activity, and then tried to draw correlations between the two.

Q. Have you prepared a chart that summarizes the different cigarette design variables that were evaluated as part of the NCI-TWG program?

A. Yes.



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Q. With reference to your chart, please explain what the NCI-TWG evaluated from a design perspective?

A. As I testified, there were over 100 different design alternatives that were tested. There were four sets of experimental cigarettes and official reports were published on each set. The first set assessed 23 modifications, including changes in paper porosity, tobacco cut width, and reconstituted tobacco. [JD-000838] The second set assessed 19 modifications, including changes in tobacco nicotine content and agronomic factors. [JD-000863] The third set assessed 27 modifications, including additives for flavor and burn rate, filtration, and tobacco substitute materials. [JD-000864] The fourth set assessed 33 modifications, including processed tobacco and stems, as well as varying cigarette nicotine content and smoke yields. [JE-067628]

Q. As an expert in cigarette design and someone who has worked in the area for 27 years, what conclusions do you draw from the results of the NCI-TWG effort?

A. The results from the NCI-TWG showed that the general reduction design techniques in the marketplace were effective, that they reduced the yields of tar, nicotine, and other target compounds, and that there were some design techniques that affected *in vitro* and *in vivo* biological activity on a per milligram tar basis.

Unfortunately, the NCI-TWG was unsuccessful in its attempt to correlate the chemistry reductions with the results from the biological assays.

Q. Why would a finding of correlations have been important to you and your colleagues at Reynolds as cigarette designers?

A. Because it would have given us guidance as to the particular compounds, and classes of compounds, on which to focus, and some guidance as to what cigarette design techniques had the potential to reduce the health risks of smoking.

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Q. What is your understanding of why the government shut down the NCI-TWG?

A. In the late 1970s, the U.S. government decided that its agenda was no longer trying to design and make safer cigarettes, but rather it was trying to get people to quit. In fact, efforts to try to reduce risks of cigarettes actually interfered with the government's new agenda of smoking cessation. So the government closed the NCI-TWG program.

Q. After the government shut down the NCI-TWG, did Reynolds abandon its safer cigarette research?

A. No, we continued doing risk reduction research.

VII. REDUCING TAR TO NICOTINE RATIOS FOR RISK REDUCTION

Q. Let's move on to another effort by Reynolds to reduce risk. You referred earlier to reducing tar to nicotine ratios. What do you mean by the phrase "tar to nicotine ratio"?

A. The "tar to nicotine ratio," or the T/N ratio, is the ratio of how much tar is yielded by the cigarette relative to how much nicotine is yielded by the cigarette. So, for example, a cigarette that yields 5 milligrams of tar and 0.5 milligrams of nicotine would have a T/N ratio of 10.

Q. Were there suggestions from the public health and scientific community about altering the T/N ratio as a way to potentially reduce risk?

A. Yes.

Q. What was the recommendation?

A. The recommendation was to reduce the T/N ratio.

Q. What does it mean to reduce the T/N ratio?

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A. Generally, there are two ways that have been investigated to reduce the T/N ratio and those are to either hold tar constant and increase nicotine, or to reduce tar and hold nicotine constant.

Q. What was the theory behind reducing the T/N ratio as a potential way to make a safer cigarette?

A. Most people believe that cigarette smoking is a health risk due to the compounds that are in tar. Assuming that is true, it makes sense to reduce tar as much as possible. At the same time, people also believe that nicotine is a very important reason why people smoke, and may be why some people smoke cigarettes with different smoke yields differently. So, if you can make a cigarette that yields nicotine at the levels that are acceptable to smokers, but minimize tar yields, that may be a safer cigarette.

Q. Have you reviewed what people in the federal government and public health community have said about reducing the T/N ratio in the course of your cigarette design work?

A. Yes.

Q. Who were some of the leading voices saying that the cigarette companies should investigate and develop reduced T/N ratio cigarettes?

A. One of the leading voices, in my opinion, was the Surgeon General. In the 1981 Surgeon General's Report, he considered an altered T/N ratio cigarette as a reasonable approach to possibly reducing the risks. Another one of the pioneers of this theory was Professor Mike Russell from the United Kingdom. He was one of the original proponents of this theory and even today continues to advocate it. Also, Dr. Gio Gori, who was Director at the National Cancer Institute and was the leader of the NCI Tobacco Working Group effort

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toward a safer cigarette, was a proponent of reduced T/N ratio cigarettes. There have been others as well.

Q. Let's discuss those further. You mentioned the Surgeon General. Let me show you JD-000636, the 1981 Surgeon General's Report, that has previously been admitted, and ask you to turn to page 58. What does the Surgeon General say about reducing the T/N ratio?

A. On page 58, he says: "It is necessary to evaluate cigarettes with lower 'tar' to nicotine ratios than are currently found in the market place. Compensation by smokers of lower 'tar' and nicotine cigarettes appears to be based on nicotine delivery. The 'tar' to nicotine ratio may limit the delivery of smoke constituents to the smoker. A low ratio might be a desirable strategy for lower risk cigarettes. It should be determined whether smoke from cigarettes with unusually low 'tar' to nicotine ratios have unusual pharmacologic or toxicologic properties."

Q. And referring to page 184 of JD-000636, what else did the Surgeon General say in 1981 about reducing the T/N ratio?

A. On page 184, he says: "Variations in 'tar' to nicotine ratios should be of special concern [citation omitted]. It is important to determine the lowest ratios that still produce a satisfying cigarette. Obviously, identical 'tar' and nicotine ratios can occur in cigarettes that have very different standard nicotine yields. Research could show if there is an optimum combination of standard yield and ratio that leads to a maximum satisfaction and minimal exposure to toxic products. Cigarettes that vary systematically in 'tar' to nicotine ratios are needed for this research."

Q. You also mentioned Professor Russell as someone else had who had recommended this research. Let me hand you JD-000752 and ask you to identify it.

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A. It is a peer reviewed article by Professor Russell and colleagues entitled "Comparison of Effect on Tobacco Consumption and Carbon Monoxide Absorption of Changing to High and Low Nicotine Cigarettes." It was published in the British Medical Journal in 1973.

Q. Are you familiar with this article?

A. Yes.

Q. Is the British Medical Journal a respected journal?

A. Yes.

Q. In this article, JD-000752, what did Professor Russell recommend?

A. He recommended a low T/N ratio cigarette. Specifically, he says at page 512: "It would then become necessary to focus on the ratio of the nicotine yield to the tar and CO yield and to consider the possibility that the safer cigarette might be the one with a high nicotine yield but low tar and CO yield."

Q. Is 1973 the only time that Professor Russell recommended a reduced T/N ratio cigarette?

A. No, he reiterated that recommendation for many years in several publications.

Q. Let me show you JD-063784, JD-063785, JD-000835, JD-000836, JD-000841, and JD-000462. What are these documents?

A. These are scientific publications from Professor Russell from the early 1970s continuing into the 1980s in which he is advocating a reduced T/N ratio cigarette as a potential way to reduce the risks of smoking.

Q. You mentioned Dr. Gori. Let me show you JD-000740 and ask you to identify it.

A. It is a 1976 article published in a journal called *Science*. The title of it is "Low Risk Cigarettes: A Prescription". The author is Dr. Gio Gori, who I've already mentioned was a director in the National Cancer Institute's Smoking and Heath Program.

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Q. Are you familiar with this article?

A. Yes.

Q. And is *Science* a respected journal?

A. It's a very respected journal, yes.

Q. Turn to page 1. What did Dr. Gori say in this article about reducing the T/N ratio?

A. Dr. Gori states that reducing the T/N ratio may make for a safer cigarette. Specifically, he says: "Within certain value ranges, high levels of nicotine, high smoke pH values and high ratios of unprotonated to protonated nicotine increase the satiation effect in the smoker, tend to depress the consumption of cigarettes and the depth and frequency of inhalation [citations omitted], and therefore reduce the intake of smoke. Thus it appears that the hazards of cigarettes can be reduced by a simultaneous reduction of tar and of its specific carcinogenic activity; by a reduction of carbon monoxide, nitrogen oxides, hydrogen cyanide, acrolein, and other undesirable toxic smoke components; and by an adjustment of nicotine levels and protonation conducive to consumer satiation."

Q. You previously testified about the NCI-TWG. Did they make any recommendations regarding reducing the T/N ratio?

A. Yes, the NCI-TWG did suggest that research needed to be done on low T/N ratio cigarettes.

Q. Dr. Townsend, let me show you JD-004162 and ask you to identify it.

A. These are the minutes of a May 5, 1976 meeting of the NCI-TWG.

Q. Did anyone from Reynolds attend this meeting?

A. Yes, as you can see from the first page, Dr. Murray Senkus, who was then the Director of Research at Reynolds, attended.

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Q. Were representatives of other cigarette manufacturers in attendance?

A. Yes, Dr. Hughes from Brown & Williamson, Dr. Spears from Lorillard, and Dr. Osdene from Philip Morris.

Q. Referring to JD-004162, what did the NCI-TWG recommend with respect to reducing the T/N ratio?

A. On page 2, "Feasibility and Desirability. It was the consensus of the group that an effort to produce and test cigarettes with tar/nicotine ratios of less than 10 is valuable and should be conducted. In view of the manipulatory potential of reconstituted sheet technology, such cigarettes are feasible. It was noted that there is currently at least one low tar, low nicotine cigarette on the market which has a tar/nicotine ratio of 10."

In the paragraph after that, it is noted: "The source of the nicotine was questioned. Dr. Tso stated that the source could be a high nicotine tobacco variety. The maximum nicotine content is 7% and although such tobacco also produces a great deal of tar it could serve as a nicotine source. The tar is not a problem if such tobacco is stripped and suitable quantities of the removed nicotine are added back to a modified tobacco sheet. Extenders could also be used to reduce tar levels."

Q. Who is the Dr. Tso who's referenced in that second paragraph?

A. T.C. Tso is a scientist who was with the U.S. Department of Agriculture for many years. He was a member of the Tobacco Working Group and had spent a great deal of his professional career researching potential modifications to the tobacco leaf in order to reduce the risks of smoking.

Q. On page 3 of JD-004162, what was discussed by the NCI-TWG regarding the form of nicotine?

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A. Under the section entitled "Nicotine Nature and Delivery," it says: "This was the pivotal issue discussed at the meeting. Nicotine has the greatest pharmacologic activity when it is in the free base form. The base form is also the 'distillable' form which readily transfers to cigarette smoke. It was suggested that the form of the nicotine could be critical in a) efficiency of transfer to smoke as base nicotine with minimal transformation to 'tar,' and b) physiological impact which depends on the base/salt nicotine ratio in the smoke aerosol (the base/diprotic salt ratio has a logarithmic dependence on the smoke pH and the two pKb's for nicotine). The question of which salt to add to the modified sheet was also raised. Nicotine citrate and tartrate were mentioned (other less acceptable salts include the acetate, oxalate and some other nicotine salts of carboxylic acids)."

Q. Now, has R.J. Reynolds conducted research on reducing the T/N ratio as has been suggested by NCI-TWG, the U.S. Surgeon General, Professor Russell and others?

A. Yes, we did. We've conducted research with high-nicotine tobaccos and we've conducted research with adding nicotine to prototype cigarettes to try to develop low T/N ratio products. We've had a number of projects over the years trying to accomplish this.

Q. What are some examples of those projects?

A. One of the largest projects that we've had was a project called XB; there was also a project called XGT. And in 2001 we were involved in a project that we called the Russell cigarette, after Professor Russell.

Q. Tell the Court about Project XB.

A. XB was started back in the 1980s. It was a very large project in which we evaluated a number of ways to make medium nicotine, low tar cigarettes, including the use of added extracts that were high in nicotine. We also evaluated adding certain acids to smooth the

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smoke by forming nicotine salts that would increase the consumer acceptability of those types of products.

Q. Has Reynolds been able to develop a consumer acceptable reduced T/N ratio cigarette?

A. No. To be clear, what I'm talking about is our efforts to go in and intentionally change the T/N ratio to a significant degree. That is something that we have not been able to do in a consumer acceptable fashion. I am excluding from this answer our efforts at general reduction which, if you recall my earlier testimony about the slightly different effect those techniques have on tar as compared to nicotine, did result in very minor changes to the T/N ratio. But, using general reduction to reduce the T/N ratio is not a consequence that we intend and is not what I'm referring to here.

Q. Have the techniques that Reynolds has investigated in the laboratory to reduce the T/N ratio, such as adding nicotine or using high-nicotine tobaccos, been used in Reynolds' commercial cigarettes?

A. No.

Q. Why hasn't Reynolds put them into actual cigarettes that are sold in the marketplace?

A. We've looked at a number of ways over the years to try to make low T/N ratio cigarettes more consumer acceptable, but so far we've been unable to do that. When we evaluated these prototypes with smokers in a consumer panel, we found that there is a fairly narrow range of T/N ratios that consumers accept. If the T/N ratio is high, those products are judged to be too weak, too mild, and without enough taste. If the T/N ratio is reduced to the low side of that fairly narrow empirical range, then those cigarettes are judged to be too strong, too harsh, and too irritating. What we've been trying to do for many years is to get

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the T/N ratio down on that low side and figure out ways to ameliorate the harsh strength response that smokers report.

Q. Is Reynolds still interested in developing a consumer acceptable reduced T/N ratio cigarette?

A. Yes.

Q. Why?

A. It is a reasonable approach to trying to reduce the risks of smoking. It continues to be advocated by various scientists today as a potential means to make a safer cigarette.

Q. Has Reynolds obtained any patents on technologies that it researched to change the tar to nicotine ratio?

A. Yes, we have. For example, in connection with our research in the late 1980s, we obtained a patent on nicotine salts.

Q. If Reynolds wanted to hide the fact that it was researching the addition of nicotine salts, would it make sense to publicly disclose that research in a patent?

A. No.

VIII. INNOVATIVE CIGARETTE DESIGN EFFORTS FOR RISK REDUCTION

A. PREMIER – RESEARCH AND DEVELOPMENT

Q. Let's now turn to another effort by Reynolds you identified to reduce the health risks of smoking and that's tobacco heating. Dr. Townsend, what do you mean by tobacco heating?

A. Tobacco heating is an idea we had at Reynolds and have pursued vigorously since the early 1980s. As I've testified, when tobacco burns, a large number of chemical compounds are formed, many of which are thought to be related to cancer and other diseases. The question we posed was whether we could invent and develop a cigarette that did not burn

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tobacco and therefore would not generate as many compounds as there are in the combustion process. The hope was that a cigarette which heated tobacco, but did not burn it, could still carry tobacco taste and nicotine through the smoke and would have simpler smoke chemistry, less biological activity, and potentially less disease risk.

Q. Why did Reynolds turn to researching tobacco heating technology?

A. If you remember back to the discussion on general reduction, the tar and nicotine yields have come down dramatically over the years, down to more than a 60 percent reduction over what they used to be in the 1950s. But in the early 1980s, we started seeing the sales weighted average flatten out because most smokers weren't continuing to trade down to lower and lower tar levels. It was at that point that we at Reynolds started looking at other ways to try to reduce risks in addition to just reducing tar and nicotine.

Q. When did Reynolds start this research on tobacco heating?

A. In about 1981.

Q. How long did it take before Reynolds had a working prototype cigarette that heated tobacco?

A. We had a working prototype within a year or two, but that was certainly far from the production version. We got to a final cigarette design over the following years and test marketed it in 1988. So it was over about a seven-year period that we developed and went to market with a tobacco heating cigarette.

Q. What was the name of that cigarette?

A. Premier.

Q. How would you characterize the Premier development effort?

A. It was a major effort. It's the largest, most intensive development effort that I've ever seen at Reynolds. There were scientists and technicians from every department of Reynolds'

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R&D who were working on Premier. Over the course of the Premier project, hundreds of people worked on it.

It was also the most secretive project I've ever seen. Given the novelty, difficulty, and potential of what we were trying to do with Premier, Reynolds' management was very concerned about the possibility of our competitors becoming aware of our research.

Q. What were the design objectives for Premier?

A. The design objectives for Premier were very clear and there were three: (1) to simplify the chemistry of the smoke as much as possible, (2) to minimize the biological activity of the smoke, and, (3) to substantially reduce environmental tobacco smoke.

Q. Did Reynolds meet its design objectives?

A. Yes, we did.

Q. Did Reynolds obtain any patents with respect to Premier and the tobacco-heating technology?

A. Yes, quite a few, actually. We obtained about 60 patents on the heating technology as well as the innovations in manufacturing processes.

Q. Have you created an exhibit that will assist you in describing the components of the Premier cigarette?

A. Yes.

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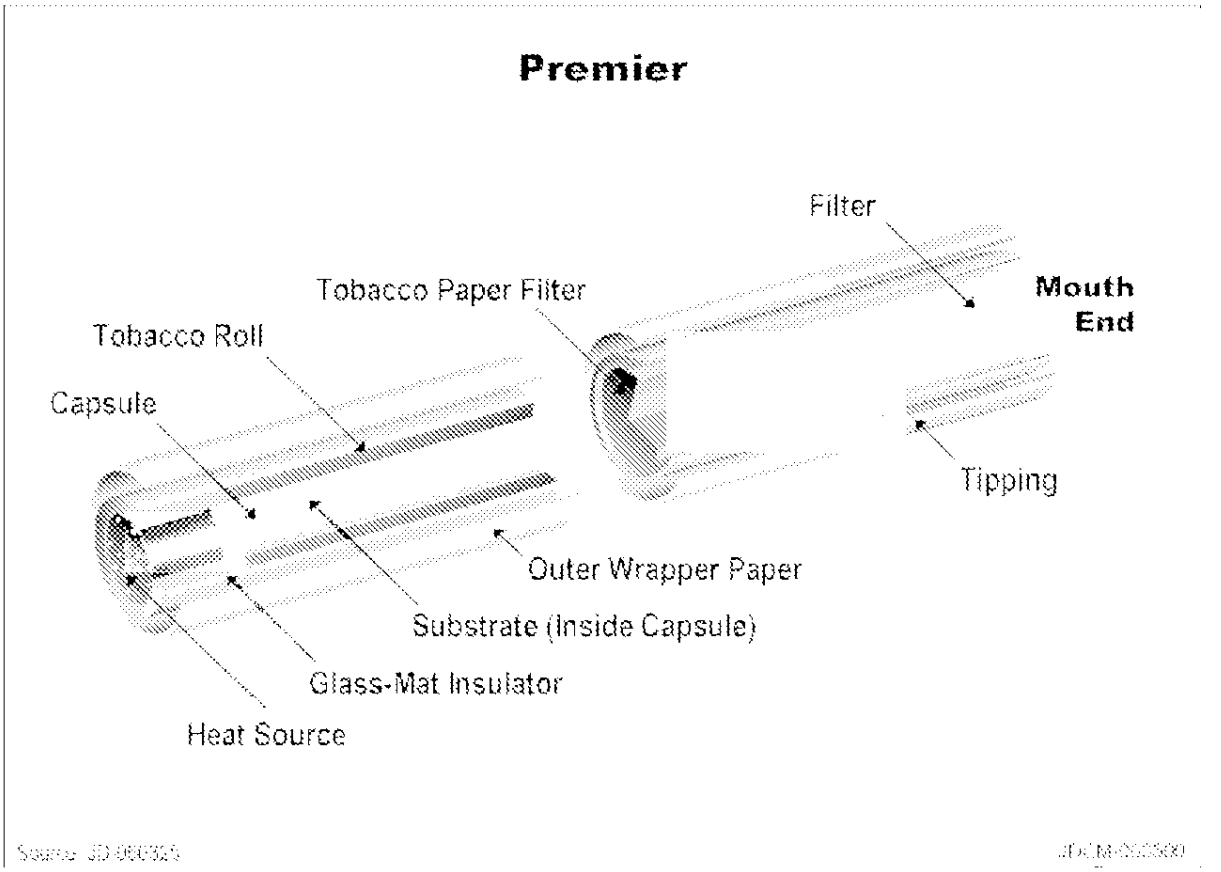

Q. With reference to your chart, please explain the construction of Premier.

A. On this chart I put a cutaway of a Premier cigarette to show how it's constructed. I have cut the cigarette first into two halves, the front half and then the mouth-end, or back-end piece, of the cigarette.

At the very front of the cigarette is a carbon heat source. It's a plug of highly refined, extruded carbon that has holes in it. And that is what burns in a Premier cigarette instead of tobacco. Around the carbon heat source, there is a glass fiber insulator mat. And that's to insulate the carbon, which gets very hot. The carbon heat source is fitted into an aluminum capsule. On the back end of the capsule are slots where the hot gases come out, then cool, condense, and form smoke. Inside the aluminum capsule are alumina beads, which are very

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small beads that have tobacco materials on the surface of them. It also contains a fair amount of glycerin. Around this aluminum jacket is a tobacco roll or a tobacco bed on the outside. And the front end is all wrapped in paper and joined to the mouth-end piece.

Turning to the mouth-end piece, there are two major segments to it. There is a folded paper or a crimped paper tobacco material. It's a lot like reconstituted tobacco. This folded paper / crimped tobacco material is joined to a very inefficient polypropylene filter. Those are wrapped with paper to hold them together and then the two pieces – the front-end and the mouth-end – are joined together.

Q. Please explain how Premier works.

A. The way that Premier works is that when a smoker lights the heat source, hot gases are drawn in through the front end of the cigarette through the heat source and into that aluminum capsule. Subsequently, the inside of the aluminum capsule becomes quite hot and the tobacco extract materials that are on the alumina beads evaporate from the alumina surface, get swept out of the capsule through those slots at the end and start to condense and form glycerin droplets. The droplets are primarily glycerin but do contain some flavors from tobacco and some nicotine. The aerosol that's formed in this region continues to pick up additional flavors and nicotine from this tobacco paper filter. There is some air that goes through the tobacco roll on the outside of the aluminum capsule, and that air picks up some additional flavors and a little bit of nicotine. The result out the mouth end of the cigarette is a smoke that is primarily glycerin with some nicotine and some tobacco flavors.

Q. Have you prepared a chart that would help explain the difference between the tar that the Premier cigarette generated and the tar from conventional cigarettes?

A. Yes, I have.

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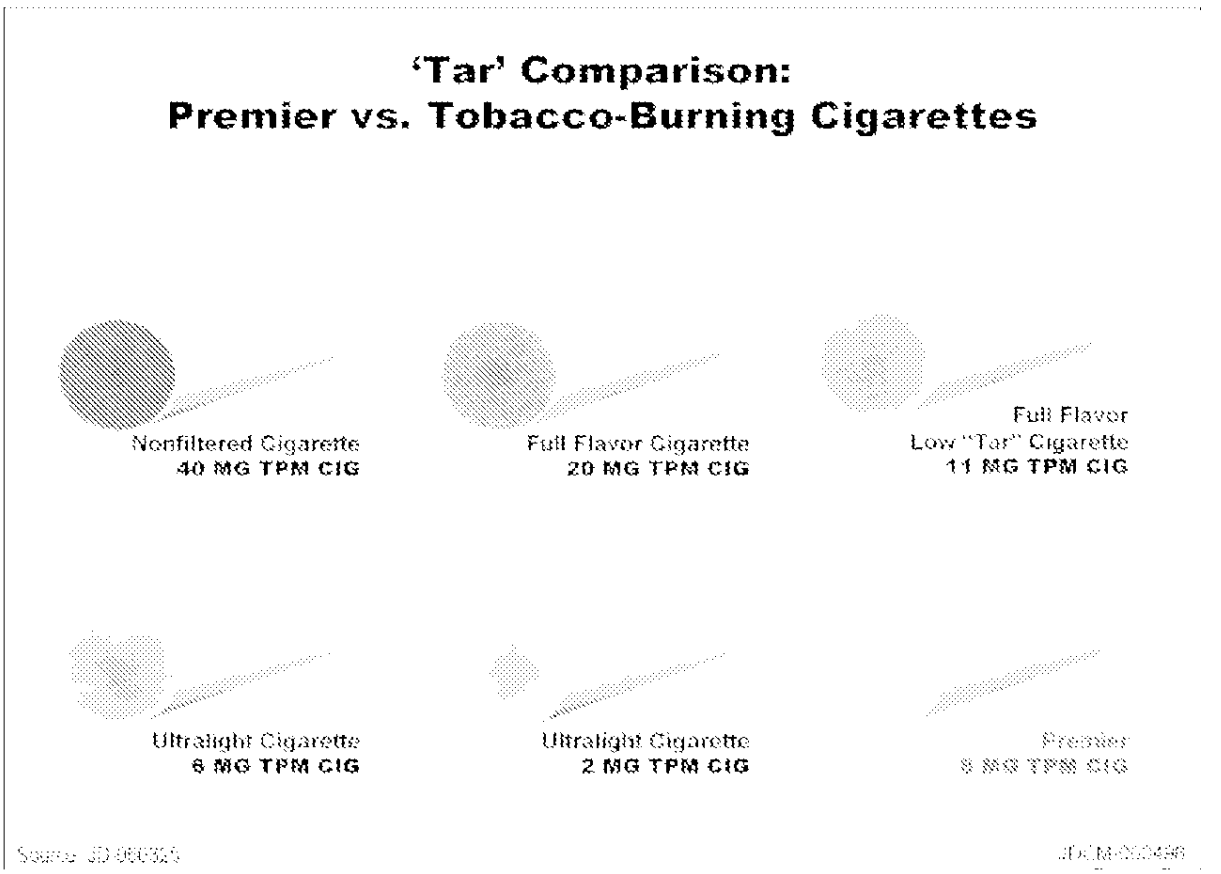

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2 Q. Doctor, using your chart, please explain how the tar from Premier compares to
3 the tar from conventional tobacco burning cigarettes.
4 A. This is a comparison of Premier versus tobacco-burning cigarettes. In particular, if
5 one looks at smoke as it passes through a very efficient filter, you'll notice that high-tar
6 cigarettes develop a very dark brown color on that filter pad as the smoke passes through. A
7 full flavor, fairly high tar cigarette of 20 milligrams of tar per cigarette develops a moderately
8 brown stain on the filter, while a full-flavored low-tar product produces less coloration.
9 When you get to the ultra light cigarettes, the color on the filter is much less. With the
10 lowest tar category, there's very little discoloration from the tar as it passes through the filter.
11 But for Premier, there was virtually no discoloration. And the reason for that is because there

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were no combustion products from burning the tobacco. And that's just a measure of the fact that the smoke was much cleaner chemically, it didn't produce that discoloration.

Q. Did Reynolds study the chemical composition of the smoke from Premier?

A. Yes, in great detail.

Q. Have you prepared a chart that will explain the reduction in a number of mainstream smoke constituents of Premier?

A. Yes.

Premier: Specific Mainstream Constituent Analyses

Compound	1R4F	Premier	Reduction %
Nicotine	0.79	0.30	62.00
Carbon Monoxide (mg/cig)	11.30	11.70	-3.50
Carbon Dioxide (mg/cig)	41.90	32.90	21.50
Hydrogen Cyanide (µg/cig)	89.00	n.d.*	99.90+
NOx (µg/cig)	294.00	11.00	95.30
Ammonia (µg/cig)	18.00	17.00	5.60
Acetaldehyde (µg/cig)	627.00	41.00	93.50
Acrolein (µg/cig)	73.00	10.00	86.30
Formaldehyde (µg/cig)	17.00	11.00	35.30
Benzene (µg/cig)	45.20	3.30	92.70
Toluene (µg/cig)	68.10	3.30	95.20
Styrene (µg/cig)	2.10	0.18	91.40
Benz[a]anthracene (ng/cig)	10.50	0.10	99.00
Benz[a]pyrene (ng/cig)	9.20	0.08	99.10
NNN (ng/cig)	101.00	8.50	91.60
NNK (ng/cig)	84.00	2.40	97.10

Compound	1R4F	Premier	Reduction %
NAT (ng/cig)	114.00	11.40	90.00
NAB (ng/cig)	18.00	1.10	93.90
NYPR (ng/cig)	14.00	0.60	95.70
Phenol (µg/cig)	6.80	0.27	96.00
o-Cresol (µg/cig)	1.80	0.03	98.30
m-Cresol (µg/cig)	1.60	n.d.*	99.90+
p-Cresol (µg/cig)	4.10	0.12	97.10
Catechol (µg/cig)	38.00	1.60	95.80
Hydroquinone	37.00	1.30	96.50
Resorcinol (µg/cig)	3.00	0.80	73.30
Pyridine (ng/cig)	2,095.00	135.00	93.60
Quinoline (ng/cig)	230.00	102.00	56.60
Acrylonitrile (µg/cig)	7.60	n.d.*	99.90+
Acrylamide (µg/cig)	1.10	2.20	-100.00
Acetamide (µg/cig)	2.20	1.80	18.20

*n.d. = not produced

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Q. With reference to your chart, please explain how Premier's smoke compared to a traditional tobacco-burning cigarette.

A. This chart shows the reductions with Premier compared to a Kentucky reference cigarette, also known in the scientific community as 1R4F. The Kentucky reference cigarette is a regular tobacco-burning cigarette that's prepared by the University of Kentucky and is a stable control cigarette that scientists can use in the laboratory. It provides a baseline that does not change from year to year.

On this chart, I have compared the yields from the 1R4F reference cigarette with Premier and then calculated the percent reductions compared to that control. Focusing in on some of the compounds I've already discussed, one can see that with Premier we achieved about a 99% reduction in BaP, a 96% reduction in phenol, a 93½% reduction in acetaldehyde, a 95% reduction in NO_X, and with respect to the tobacco specific nitrosamines, NNN, NNK, NAT, and NAB, all are in the range of a 90-plus% reduction. In addition, there were reductions in many other compounds that we haven't discussed previously, such as a 99% reduction in hydrogen cyanide, nearly a 93% reduction in benzene, and a 99% reduction in acrylonitrile. There were two compounds, CO and acrylamide, for which we saw an increase.

Q. In addition to measuring the reductions in particular smoke constituents, did Reynolds conduct additional smoke chemistry tests?

A. Yes, for example, we also looked at chromatographic profiles of Premier smoke compared to tobacco-burning smoke.

Q. What do you mean by chromatographic profiles?

A. Chromatography generally refers to separating compounds into their component parts so that they can be analyzed. There are many ways to do chromatography. At Reynolds, we

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refined a method called Multi-Dimensional Gas Chromatography for use in analyzing complex mixtures like cigarette smoke. We published our work on this method. When you perform chromatography, the resulting data can be portrayed in a graph-form called a "chromatographic profile" and the shape of that profile depends on the composition of the mixture being analyzed. A chromatographic profile can be used to make comparisons between complex mixtures in terms of the number of compounds present and their relative amounts. Using this technique, we generated chromatographic profiles of the smoke from Premier and tobacco-burning cigarettes.

Q. What did you learn about Premier based on the chromatographic profiles?

A. The chromatographic profiling showed that Premier's smoke was much less complex in terms of the number of components found in our studies. Specifically, we found that the number of components detected in the particulate phase of Premier's smoke was 94% less than the number of components detected in 1R4F, the reference cigarette. In the vapor phase, there were 83% fewer components detected with Premier compared to 1R4F. So, this testing showed that Premier's smoke was simpler.

Q. As a cigarette designer, what do you conclude about Premier based on the smoke chemistry testing Reynolds performed?

A. It is clear that Premier's smoke contained fewer compounds and, for those compounds that were present, virtually all of them occurred at levels dramatically less than the reference cigarette. This was a significant step forward.

Q. Besides smoke chemistry, what other types of testing did Reynolds conduct on Premier?

A. We conducted extensive biological and toxicological testing of Premier, both *in vitro* and *in vivo*. Also, we performed several experiments with smokers.

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Q. What *in vitro* tests did Reynolds conduct on Premier?

A. Reynolds conducted a battery of *in vitro* genetic toxicology tests on Premier, including Ames testing, Sister Chromatid Exchange testing, Chromosomal Aberrations testing, HGPRT specific gene locus testing, and Unscheduled DNA synthesis testing.

Q. How did Premier perform in each of the *in vitro* genetic toxicology tests?

A. Premier showed no genotoxicity in any of the tests.

Q. What *in vivo* toxicology tests did Reynolds conduct on Premier?

A. Reynolds conducted a battery of *in vivo* genetic toxicology tests on Premier, including Sister Chromatid Exchange testing, Chromosomal Aberrations testing, Micronucleus assay testing, and urine mutagenicity testing.

Q. How did Premier perform in each of these *in vivo* genetic toxicology tests?

A. Premier showed no genotoxic activity.

Q. Did Reynolds perform any inhalation studies of Premier with animals?

A. Yes, we conducted a total of seven (7) inhalation studies, three 14-day inhalation studies and four 90-day inhalation studies. These studies used both hamsters and rats.

Q. How did Premier perform in the inhalation studies?

A. In these tests, Premier produced significantly fewer and less pronounced biological effects than the tobacco-burning reference cigarettes.

Q. What tests did Reynolds perform on Premier with smokers?

A. We tested smoking behavior and nicotine pharmacokinetics, as well as urine mutagenicity.

Q. Why did Reynolds assess nicotine pharmacokinetics?

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A. Because the smoke from Premier was so different from the smoke of tobacco-burning cigarettes, we wanted to assure ourselves that nothing unusual occurred when smokers would smoke Premier, so we measured smokers' nicotine absorption, metabolism and elimination.

Q. What did the smoking behavior and nicotine pharmacokinetic studies with smokers show?

A. Although smokers smoked Premier more intensively than the tobacco-burning reference cigarettes, in general, there was little qualitative difference in nicotine absorption, metabolism and elimination. So, we were confident that Premier's smoke would be treated by smokers' bodies in the same way as the smoke from tobacco-burning cigarettes.

Q. What did the urine mutagenicity studies with Premier show?

A. The urine from smokers of Premier had the same mutagenicity as that of non-smokers. On the other hand, when subjects smoked tobacco-burning cigarettes, their urine was significantly more mutagenic than when smoking Premier.

Q. Did Reynolds publish the results of its chemical, biological and toxicological research on Premier?

A. Yes. We published a lot of research in the peer-reviewed literature, and presented papers at scientific meetings. We also published a 743-page monograph that compiled all of our scientific studies on Premier.

Q. Let me show you JD-060325. Please identify it for the Court.

A. This is the Premier Monograph that was published by Reynolds. We provided it to scientists around the country, not only people who were actively conducting tobacco research, but also people in the public health community and others.

Q. Why did Reynolds publish over 700 pages of research on the Premier cigarette?

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A. Because, number one, we conducted a lot of research and the results suggested to us that we had been successful in meeting our design criteria of simpler chemistry and reduced biology. And we felt it was important for the scientific community to see everything we did, including details about the design as well as the evaluation, to make it possible for the scientific community to judge for themselves the merits and potential benefits of Premier.

Q. Was the research in the Premier Monograph subjected to peer review?

A. Yes. We had a committee of 12 outside experts who peer-reviewed it. They evaluated all the chemistry, biology, and the human studies, and made sure that the science was first-class and that we had met our design objectives.

Q. Were your reviewers tobacco company employees?

A. No, these were scientists principally from universities who independently reviewed all of the work in this Monograph.

Q. How did you get these independent scientists to come and be willing to give all their time to review 700 pages of research and everything behind it?

A. We asked them to and, certainly, we paid them an honorarium for their time.

Q. Who were the scientists on the peer review committee?

A. They are listed, with their affiliations, on pages xiii-xv of the Monograph, and they were: Dr. James Crapo, Duke; Dr. John Doull, University of Kansas; Dr. Ronald Estabrook, University of Texas; Dr. Dietrich Hoffmann, American Health Foundation; Dr. Robert Neal, Chemical Institute of Toxicology; Dr. Herbert Rozenkranz, Case Western Reserve University; Dr. Thomas Slaga, University of Texas; Dr. Robert Squire, Johns Hopkins; Dr. Steven Tannenbaum, MIT; Dr. Mark Utell, University of Rochester; and Dr. Gerald Wogan, MIT.

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Q. You've mentioned Dr. Dietrich Hoffmann several times in your testimony. Can you tell the Court a little bit about Dr. Hoffmann's background?

A. Dietrich Hoffmann is a prominent scientist that has spent essentially his entire career studying smoke chemistry, understanding cigarettes and pushing for safer cigarettes. He worked with Dr. Ernst Wynder at the American Health Foundation for many years.

Q. Do you personally know Dr. Hoffmann?

A. Yes, I've spoken with him many times. I've shared the results of some of our research with him to get his input. Dr. Hoffmann and I have also been on some of the same expert committees regarding cigarette design issues.

Q. What did the peer review committee that looked at Reynolds' research on Premier conclude?

A. The committee concluded that Reynolds had met its design objectives of a significant simplification of mainstream and sidestream smoke chemistry, minimizing biological activity and a substantial reduction in environmental tobacco smoke, or ETS. Specifically, their conclusions were stated on page x of the Monograph: "The committee considered these objectives to be commendable and concluded that they have been substantially achieved through the research and development program, as represented by the information presented to the committee for review."

B. GOVERNMENT AND PUBLIC HEALTH REACTION TO PREMIER

Q. What was the reaction of the scientific community to the introduction of Premier?

A. It was mixed. Some scientists thought this was a major step forward in reducing the risks of smoking, but there were also a number of scientists who attacked Premier.

Q. Let me show you JD-001592 and ask you to identify it.

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A. This is a September 16, 1988 letter about Premier from then Surgeon General, Dr. C. Everett Koop, to Frank Young who was the commissioner of the Food and Drug Administration at the time.

Q. In his letter to FDA, what did Dr. Koop say regarding Premier?

A. On page 1, "I commend your action to inform the R.J. Reynolds Tobacco Company (RJR) that if it decides to market its new product, Premier, it does so at its own risk."

Also on page 1, "Product health claims are implicit. In its public statements and marketing plans, RJR states regarding the product: 'a majority of the compounds produced by burning tobacco are eliminated or greatly reduced, including most compounds that are often associated with the smoking and health controversy.' To me, this suggests a health claim that the product is 'safe' or 'safer' than conventional products, which could result in reduced quitting by smokers, increased relapse by ex-smokers, and increased initiation by adolescents."

On page 2, "In conclusion, I consider this product to be a nicotine delivery system for which health claims are being made and urge you to exercise jurisdiction over it as you have over other novel nicotine delivery systems. I do not believe that marketing this product is in the best interest of public health."

Q. Did any public health organizations take a position on Premier?

A. Yes. For example, the American Medical Association petitioned the FDA opposing Premier, as did other public health groups.

Q. Let me show you JD-060554 and ask you to identify it.

A. This is the petition from the American Medical Association to the FDA opposing our sale of Premier.

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Q. Let me show you JD-000557, a document produced by the Government in this case. It's title is "Office on Smoking and Health. Minutes from October 3, 1989 Meeting. 'New Tobacco Products'". Have you seen this before?

A. Yes, I've reviewed it.

Q. On page 4 of JD-000557, there is a reference to Dr. Gregory Connolly. Who was Dr. Connolly at the time?

A. He was with the Massachusetts Department of Public Health at the time and worked there for many years thereafter.

Q. On page 6, of JD-000557, it states: "Dr. Connolly said that anti-smoking groups should not wait for scientists to complete research on the new brands and products. Opportunities currently available to coordinate a campaign against the new products might be missed if there is a delay. He suggested acting while the new tobacco products are being publicized. Banning advertising would be a step in the right direction. Research should continue, but there is no need to wait for the results to initiate a war against new tobacco products." Do you see that?

A. Yes.

Q. At the time that you and your colleagues were researching and developing cigarettes like Premier, were you aware that there were discussions within the federal government about initiating war against new tobacco products without waiting to see what research would show about the products?

A. No.

Q. In contrast to what we've discussed about various government and public health community reactions, were there others in the public health and scientific community that responded favorably to Premier?

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A. Yes.

Q. Let me show you JD-060309 and ask you to identify it.

A. This is a letter dated May 7th 1993, from Professor Michael Russell to Carl Ehmann who was the head of Reynolds' R&D at the time. Professor Russell enclosed a copy of a peer-reviewed study that he conducted on Premier.

Q. You mentioned a Professor Russell from the Institute of Psychiatry in London earlier in your testimony. Is that the same Professor Russell who authored JD-060309?

A. Yes.

Q. And was JD-060309 maintained in the regular course of Reynolds' business?

A. Yes.

Q. Please read from the first page of Professor Russell's letter the sentence from the first paragraph beginning with "Basically."

A. Dr. Russell says: "Basically, I think the Premier has tremendous potential for low risk long-term nicotine use and that the response to it in your country was political and irrational. However, the Premier product which your company market-tested, was handicapped by its low nicotine delivery and its strange taste. I realize also that your company was handicapped in being unable to promote it as a safer product."

Q. Please read the last sentence of that same paragraph.

A. "Our advisory committee on Smoking and Health is aware of and accepts the need to maintain nicotine deliveries while achieving further reductions in more harmful components in their programme for lower risk cigarettes."

Q. Please read the first sentence of the last paragraph on the first page.

A. "I write because in my view it would be very sad if you were to abandon further development of such a potentially valuable product."

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Q. What is the significance to you as a cigarette designer of the conflicting opinions held within the public health community regarding Premier?

A. First of all, it was very surprising because I thought that the scientific community would agree that Premier really was a major step forward. So at first I was surprised, and then certainly frustrated because of all the attacks on Premier. There is no doubt in my mind from the science that Premier was a major step forward in reducing the risks of smoking. Now, it's a very different cigarette design that consumers had difficulty accepting, but the attacks were very frustrating.

C. PREMIER TEST MARKET

Q. Was Premier introduced into test markets by Reynolds?

A. Yes. The Premier cigarette was introduced into test markets in the latter part of 1988.

Q. Where was Premier test marketed?

A. We took it to three cities: St. Louis, Tucson and Phoenix. And in those three areas, there was widespread distribution, there was also advertising and other marketing initiatives for Premier.

Q. How did Premier fare in the test markets?

A. It failed.

Q. Why did Premier fail?

A. It failed for several reasons. The first was that the taste really was different. And you can imagine when you're heating tobacco and not burning it, you're going to get a very different taste. Many consumers didn't like that taste. A few got used to it but not many. Another factor was that the product doesn't burn down. When you smoke it, only the carbon tip burns. And it was a very difficult adjustment for many smokers to get used to a product that doesn't burn down. It stays the full length. It just quits generating smoke after awhile.

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But, smokers struggled with knowing when the cigarette was done, unlike a traditional cigarette which burns down. So there were some major differences in the product.

And then a third and very important factor was the widespread condemnation of Premier by various people in the government and public health community. Those critiques and attacks on Premier were picked up by the press across the country, including the press in the test markets, and smokers were very concerned about what they were hearing. Premier was not well-received in the test markets, either by the press or by smokers.

Q. Returning to JD-000557, the meeting minutes memorandum from the Office on Smoking and Health, on page 2, there's a reference to Judith Wilkenfeld. Who was Ms. Wilkenfeld at the time?

A. She was an attorney with the Federal Trade Commission.

Q. On pages 10 and 11 of JD-000557, it states: "As another approach to fighting new tobacco products, Ms. Wilkenfeld suggested preparing a statement on the new products and having representatives of anti-smoking organizations sign it and forward it to Congress. Ms. Wilkenfeld pointed out that even when the FTC and FDA cannot do anything directly to prevent the distribution of the new tobacco products, the publicity that is generated by complaints about the lack of an immediate Federal response is helpful. She believes that this publicity is very useful, because it publicizes the debate about the health consequences of the new tobacco products. The negative publicity drawn to Premier was partly what caused its demise, according to Ms. Wilkenfeld." Do you agree with Ms. Wilkenfeld that the negative publicity drawn to Premier was partly what caused its demise?

A. Yes, that was part of the reason.

Q. Did Reynolds do anything to try to fix the taste and acceptability of Premier?

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A. Yes, we did.

Q. What are some examples of how Reynolds tried to improve the taste and acceptability of Premier?

A. Throughout Premier's development, we knew there were taste issues. We tried using different types of flavors and flavoring materials, but they will not create a tobacco flavor or a cigarette-type flavor by themselves. They will add certain flavor characteristics or aroma characteristics that can modify the taste signature of tobacco, but you can't start out with a pure tobacco heating system and add some magic flavor that will automatically give you tobacco taste. We tried it for many years. We thought we could do it, and we weren't able to.

Q. Let's set aside Premier's commercial failure for the moment. Would it have been technically feasible to develop Premier earlier than it was developed?

A. No. In fact, some of the technologies that are in Premier were not invented until right before we started working on Premier. An example is the alumina beads, which just simply weren't available before the 1980s, and yet were very important in how Premier performed. The glass fibers in the insulator mat were specially designed for Premier, and really were a break-through item. We had to invent new machines to manufacture Premier and we worked with a number of different suppliers, design engineers and our own internal design engineers to actually make that happen. The machinery to insert the heat source into the aluminum capsule is something that we developed together with some equipment manufacturers that we had never worked with before, like Bosch, who makes automobile equipment.

Q. Based on your 27 years as a cigarette designer and product developer, what conclusions do you draw from Reynolds' experience with the Premier cigarette?

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A. What we learned goes back to consumer acceptability and commercial feasibility. We designed and constructed a cigarette that has the potential to reduce risks and that I believe reduces risk based on the science. However, it was a very different cigarette. And consumers, at least in the test market, did not accept those cigarettes because of the differences, they didn't get used to it, and consequently it failed. So consumer acceptability is extremely important.

Q. How much money did Reynolds spend researching, developing and test-marketing Premier from beginning to end?

A. The total cost in going from idea to test market was in the neighborhood of a billion dollars. That includes not only the R&D but the manufacturing development, the process development, materials development and all the test marketing expenditures.

D. ECLIPSE – RESEARCH AND DEVELOPMENT

Q. With the failure of Premier, did Reynolds stop working on tobacco heating cigarettes?

A. No, we did not give up on the technology.

Q. What happened next?

A. We tried to learn from our experience with Premier, in particular its failure in the marketplace. So we talked to people who tried it in the test market. We talked to smokers who bought the product, but who didn't like it. We also spoke to smokers who accepted the product to understand why they did. Next we tried to improve the taste characteristics dramatically. The main approach that we took was to burn a small amount, and a controllable amount, of tobacco to give some tobacco taste, some cigarette taste, but still keep the smoke chemistry yields very low, and keep the biological activity really low.

Q. Did Reynolds eventually develop an improved version of Premier?

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A. Yes, we did.

Q. Did that cigarette have a name?

A. Yes, it's called Eclipse.

Q. What are the general similarities and differences between Eclipse and Premier?

A. Basically, both Premier and Eclipse use a carbon heat source surrounded by a fiberglass mat for insulation, but with Eclipse we have taken out the aluminum capsule and the substrate, and replaced them with a bit of highly processed tobacco. Eclipse also has a second bed of highly processed tobacco. Both beds of tobacco are intended to give flavor and to deliver a little bit of nicotine in the smoke of the Eclipse. The tobacco beds include a fairly high level of glycerin because glycerin is the primary smoke former and it's a relatively inert or innocuous material.

In addition to that, with Eclipse we did mix a very small and controllable amount of tobacco in with the carbon heat source. Also, there is a very small piece of reconstituted tobacco paper that's wrapped around the heat source. When the cigarette is lit, it will burn that small piece of paper and the carbon that's in there. So the intent is for that small amount of tobacco, when it's burned, to give some tobacco taste. But that tobacco is burned quickly and then the rest of the smoking process is just hot gases from the carbon going through the two tobacco beds picking up tobacco taste, flavors, nicotine, water and glycerin.

Q. Why did you put a small amount of tobacco in Eclipse when you didn't do it with Premier?

A. To improve the taste characteristics, to give it more normal tobacco taste, and to try to improve consumer acceptance. But again the goal was to keep that amount of tobacco low so that there were still major reductions in chemistry and biology.

Q. Would it have been possible to develop the Eclipse cigarette any earlier?

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A. No, I don't think so, in part because of the science that we learned from Premier, the new construction materials and processes that were necessary, and the new approach that we took with developing Premier. I don't think it would have been possible at all to develop Eclipse any earlier.

Q. Did Reynolds conduct any chemical and biological tests with Eclipse?

A. Yes, we undertook an extensive testing program.

Q. In general, what testing did Reynolds conduct?

A. We did extensive chemical testing looking at the smoke composition, and looking at a number of different compounds that are in smoke that the public health community and others have identified as possible reasons why smoking presents disease risk. We did extensive biological testing in laboratory *in vitro* studies looking at a variety of different assays, then we also conducted studies with animals, both inhalation tests and skin painting tests. In addition, we conducted extensive tests with smokers, looking at the effects of switching to Eclipse on certain biological end points. We have actually done more extensive testing with humans smokers on Eclipse than we did with Premier. Finally, we took all of that information to an outside scientific advisory board for their review and comment.

Q. With respect to the smoke chemistry testing, have you prepared a demonstrative that will show the results of those tests?

A. Yes. I have a chart showing the construction of Eclipse, and also some of the reductions observed in chemistry.

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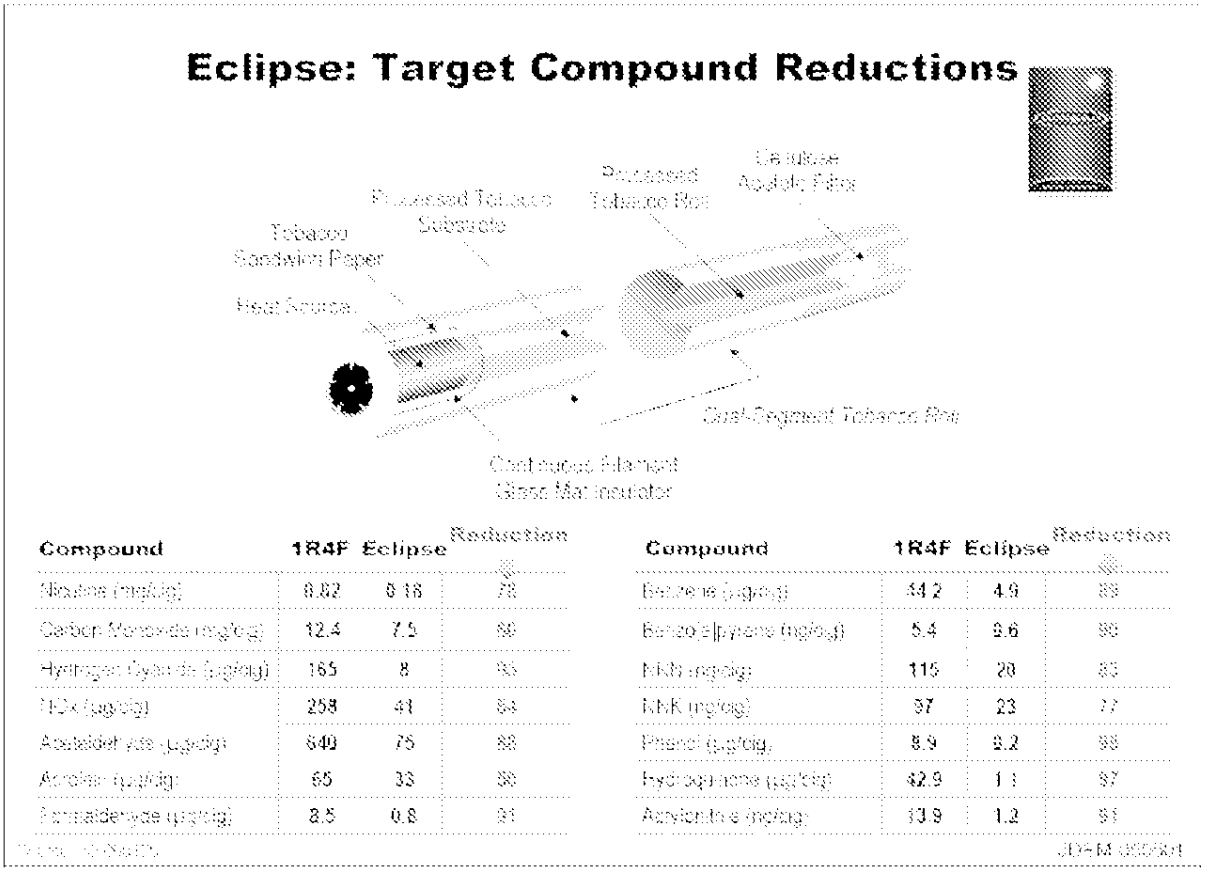

Q. With reference to your chart, please explain Reynolds' accomplishments with Eclipse in terms of smoke chemistry.

A. First of all, in the top half of the drawing is a cutaway of the Eclipse product as I have already described it. The bottom half contains a table showing some of the chemistry reductions that were observed for Eclipse.

Looking at the drawing of the construction of Eclipse, you will see the heat source, and that we have replaced the aluminum capsule used in Premier with a tobacco bed of highly processed tobacco. Then there is a second bed, the filter section, and finally there is a small mouthpiece filter that actually has a hole down the middle so there is really very or essentially no removal efficiency by that mouthpiece filter.

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Now, if you turn to the table, you will see major reductions. Even though we are burning a small amount of tobacco in the heat source and around the heat source, there are still major reductions in the chemistry. Looking at, for example, benzopyrene, there is about a 90 percent reduction. Benzene, a compound that's thought to be a human carcinogen, shows about 89 percent reduction. Acetaldehyde is reduced about 88 percent. Nitrosamines show about an 80 percent reduction.

Q. Let's turn to the biological tests on Eclipse. What were the results?

A. We saw major reductions in the *in vitro* tests that we conducted. When we turned to animal studies, we saw a major reduction in mouse skin painting tumorigenicity. We saw major reductions in the results of the inhalation studies with animals. All together, there were significant reductions in the biological tests that we conducted.

Q. Who performed the biological tests?

A. Most of the biological tests were conducted in-house at R.J. Reynolds. We did contract out some testing in order to replicate what we did in-house to get confirmation of our results.

Q. You also mentioned tests conducted on smokers. What were those tests and what did they show?

A. There were a number of tests conducted with smokers that we contracted out to research laboratories, primarily at universities. For example, the University of Nebraska did an extensive test, we contracted some research at Tulane, the University of British Columbia, and a number of other places. And we did some work in-house.

One of the results that we found with smokers was a major reduction in urine mutagenicity. So the mutagenic activity of urine from smokers who switched to Eclipse was greatly reduced, which indicated a reduced exposure to mutagens. In the University of

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Nebraska study, there was research that looked at irritation in the lung and actually showed a major reduction in lung irritation, which is thought to be related to cancer formation, for those smokers who switched to Eclipse. Samples were actually taken from the smokers' lungs to analyze and that showed reduced irritation. There was also some research done looking at DNA adduct formation in those samples. Again, showing major reductions.

E. ECLIPSE COMMERCIAL AVAILABILITY

Q. Has Reynolds introduced Eclipse into the market?

A. Yes, we started test marketing Eclipse in 1996 in Chattanooga, Tennessee. Over succeeding years, we added some additional test markets, such as in Nebraska and Georgia. In April 2000, we greatly expanded Eclipse with a retail test market in the Dallas/Fort Worth area, and we made it available via the Internet in the 38 states that allow mail-order sales.

Q. Where is Eclipse being sold currently?

A. Eclipse is available nationwide at retail in certain chains, such as 7-Eleven and Circle K. So, it is not in every cigarette outlet across the country, but it is available in select locations in every state.

Q. How has Eclipse done in the marketplace?

A. It is not doing well at all, but we've got a relatively small number of smokers nationwide that have switched and smoke only Eclipse. We get testimonials and some feedback from those smokers about Eclipse. So, it is struggling, particularly because it's still a different taste, it's still hard to light, and it doesn't burn down. So it's a very different experience than with the tobacco burning cigarette. But what we are finding is that slowly some smokers are adjusting to those differences. They are adapting, they are getting used to it, and have grown to like the much lighter taste of Eclipse.

Q. At the current sales level, is Eclipse profitable?

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A. No, we are losing money on Eclipse.

Q. Do you know yet whether you have commercial feasibility for Eclipse?

A. We don't know yet. I'm optimistic. I think the national distribution of Eclipse is a plus for the product. We are still getting awareness out there, getting people to try the product, getting people to tell other people about the product. So I think it's still too early to tell, but I certainly hope that it is commercially feasible.

F. R.J. REYNOLDS' FOUR STEP METHODOLOGY

Q. Dr. Townsend, in response to an earlier question, you testified in effect that, after Premier, in the absence of objective standards or criteria from the government or the scientific community, Reynolds set about trying to define for itself what constitutes a reduced risk cigarette, and what types of tests you must conduct to demonstrate that there is reduced risk potential. What has Reynolds done to try to determine how to demonstrate a potential reduction in risk?

A. We developed a protocol that we call the Four Step Methodology. When we have a product modification that we think has the potential to reduce the inherent risks of cigarette smoking, before we implement that innovation and make advertising claims about it, we subject it to the Four-Step Methodology. We will not make any reduced risk claim unless it can be substantiated by the Four-Step Methodology.

Q. Please describe Reynolds' Four Step Methodology.

A. It is a tiered-testing approach to product evaluation. The first step involves an extensive understanding of smoke chemistry. If the chemistry shows a simplification of the smoke, or dramatic reductions in key target compounds, we'll follow that up with biological testing. Using a battery of tests, both *in vitro* and *in vivo*, we assess the new cigarette to see if it shows significant reductions in biological activity. If we show that, then we will conduct

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studies with human smokers to see if there are indications that as the product will be used, there is evidence that it may present less risk. For example, we may assess lung inflammation to see if we've made a difference. Finally, if all of the chemistry, biology, and tests with smokers prove to our scientists, by a weight of the evidence standard, that the new design has the potential to reduce risk, we will then present all of our data to an external panel of outside experts to get their assessment. After reviewing the data, the expert panel will tell us whether, in their judgment, we've developed a cigarette that they agree presents less risk.

G. ECLIPSE MAY PRESENT LESS RISK OF CERTAIN DISEASES

Q. Have any of Reynolds' cigarettes been subject to testing pursuant to the Four Step Methodology?

A. Yes, and the best example is Eclipse.

Q. You've already testified regarding the chemical tests, biological tests, and tests with smokers that Reynolds conducted with Eclipse. As part of its Four Step Methodology, did Reynolds submit all of that data to an outside expert panel?

A. Yes, we did.

Q. And did the expert panel issue a report regarding their conclusions with respect to Eclipse?

A. Yes, they did.

Q. Let me show you JD-060235 and ask you to identify it.

A. This is the report from the expert panel regarding Eclipse.

Q. Is the expert report publicly available?

A. Yes, it was published in Inhalation Toxicology, a peer reviewed scientific journal.

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Q. With reference to JD-060235, what did the expert panel conclude with respect to the potential health benefits of Eclipse?

A. On page 32, the expert panel stated: "Although there is no widely accepted single test for assessing the potential of a particular cigarette to cause cancer, the weight of evidence from accepted standards (*in vitro*, *in vivo* tests) suggests that Eclipse presents a diminished risk for cancer as compared to tobacco-burning cigarettes."

On page 32, the expert panel also stated: "Therefore, the reduced inflammation of airways of laboratory animals in inhalation studies, the reduced irritancy of upper airways in mice, the reduced cytotoxicity of Eclipse smoke and smoke condensate in *in vitro* studies, and the decreased vapor-phase free radicals, cytotoxins, and irritants in Eclipse smoke indicate Eclipse may also present less risk for chronic obstructive pulmonary disease (COPD), i.e., chronic bronchitis and emphysema."

Q. You previously testified that the scientific data on Premier was shared with a peer review committee of outside scientists and that their statement was included in the Premier Monograph, JD-060325. With respect to the potential health benefits of Reynolds' tobacco-heating cigarettes, how did the report you received from the committee on Premier compare to what you were told by the Eclipse panel?

A. As I've just shown, the Eclipse expert panel told us pretty clearly that Eclipse may present less risk for a number of serious diseases. The committee of experts who looked at Premier only concluded that we had met our development objectives of simpler chemistry, reduced biological activity, and a reduction in ETS. But, that committee did not make any judgments regarding the potential health benefits of Premier.

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Q. After having received these conclusions from the expert panel regarding Eclipse, did Reynolds take any steps to inform consumers of the potential risk reducing benefits of Eclipse?

A. Yes, we did.

Q. What did Reynolds do?

A. Since April 2000, when we started our test market in Dallas/Fort Worth and made Eclipse available via the Internet, we have expressly stated that Eclipse may present less risk of cancer, chronic bronchitis and possibly emphysema.

Q. How has Reynolds communicated to consumers that Eclipse may present less risk of certain diseases?

A. In advertisements, point of sale materials, and via the Internet at a website dedicated exclusively to Eclipse, www.eclipse.rjrt.com. In addition, we have a website for scientists and medical doctors that contains our research on Eclipse, www.eclipsescience.com.

Q. Let me show you JD-061302. Please identify it.

A. This is one of our advertisements for Eclipse that we first used in April, 2000.

Q. In this advertisement for Eclipse, what did Reynolds tell smokers?

A. "The best choice for smokers who worry about their health is to quit. Here's the next best choice." The rest of the advertisement describes Eclipse and its attributes.

Q. What other information is contained in the Eclipse advertisement?

A. "This is not a cigarette for people who want to avoid the risks of smoking. No cigarette is without risk. And it's not for people who want to quit. This is for smokers who have been waiting for a cigarette that responds to certain smoking-related illnesses including cancer. It's called Eclipse, a new cigarette from R.J. Reynolds Tobacco Company. And while it's not an alternative to quitting, it is a better way to smoke." We also present our

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conclusions about Eclipse: "Eclipse may present less risk of cancer. Eclipse produces less inflammation in the respiratory system, which suggests a lower risk of chronic bronchitis, and possibly even emphysema."

Q. I want you to assume Dr. Townsend that the Government in this case is claiming that the defendants had an agreement not to compete with one another on the basis of health. How does that allegation square with what Reynolds is doing currently with Eclipse?

A. Clearly, with Eclipse, we are competing based on the potential health benefits of Eclipse.

Q. To your knowledge and personal experience over 27 years with Reynolds, did you ever hear of an agreement with the other cigarette companies not to compete based on health?

A. No, I've never heard of anything like that at Reynolds.

IX. CRITICISMS OF THE MODERN LOW TAR CIGARETTE

Q. Dr. Townsend, I now want to turn to the allegations that have been made in this case regarding cigarette design and I want to start with low tar cigarettes. You previously mentioned the fact that the development of low tar cigarettes, which were heavily endorsed by the government, have recently come under attack by some within the public health community — do you recall that?

A. Yes, I do.

Q. What is your understanding of the nature of the main criticisms of cigarette design efforts to lower tar?

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A. There are a number. One criticism relates to whether human smokers of cigarettes with lower FTC smoke yields actually take in less smoke, or whether smokers compensate completely for any reduction in yield and as a result do not take in less smoke.

A second criticism relates to whether Reynolds, and the other cigarette manufacturers, intentionally design cigarettes in such a way to facilitate compensatory smoking behavior.

A third criticism relates to whether "light" cigarettes, on an equal weight of tar basis, are actually higher in risk than full-flavor cigarettes.

A. COMPENSATORY SMOKING BEHAVIOR

Q. Are you familiar with a scientist named Dr. Michael Dixon?

A. Yes, he is a scientist at British American Tobacco in England.

Q. Do you understand that Dr. Dixon has been designated by the Defendants in this case to testify as an expert on smoking behavior and compensation?

A. Yes, I do.

Q. Has Reynolds conducted research on the issue of compensation?

A. Yes.

Q. Have scientists at Reynolds published the results of their research in the peer review literature or presented it at scientific conferences?

A. Yes.

Q. Let me show you JD-000675 and JD-000391. Please identify these exhibits for the Court.

A. They are 2 of Reynolds' publications regarding human smoking behavior.

Q. In the course of your work, did you discuss compensation with the Reynolds scientists who studied human smoking behavior?

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A. Yes.

Q. What advice did they give you regarding whether smokers compensate?

A. That smokers can compensate and some do.

Q. What do you mean?

A. My understanding is that when most people switch to cigarettes with lower FTC yields, they tend to puff those cigarettes harder, taking bigger puffs, more frequently. As a group, smokers who switch to lower yielding cigarettes do not reduce their exposure, or smoke intake, to the same extent as the reduction in FTC yield. For example, let's assume someone smokes a full-flavor cigarette that has an FTC tar of 15 mg in the same way as the FTC machine, such that it yields 15 mg tar. If you switch that person to a light cigarette with an FTC yield of 10 mg tar, the compensation theory says that person would change how they smoke and would generate more than the FTC determined 10 mg tar.

Q. Because of the compensation phenomenon, in your view, does that mean that the cigarette design technologies that Reynolds has implemented to reduce FTC tar yields by more than 60% over the past 5 decades, are absolutely useless to smokers?

A. No.

Q. Why not?

A. Because I believe that people who do switch to lower tar cigarettes, on average, get less tar as a group. Although compensation can and does occur, on a population basis, smokers of lower tar cigarettes are getting less. That doesn't mean that everyone gets less; there may be some people who do switch to lower tar cigarettes who do not get less. But, on average, people get less.

Q. What is your understanding of the public health community's view over time regarding the extent of compensation?

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A. For many years, the published scientific literature on smoking behavior showed that compensation was incomplete. And, that was the conclusion of most scientists. More recently, some scientists have questioned the results of all of those studies and now conclude that compensation is complete. I do not believe that this change in view was because of some new scientific data, but rather was based on a reanalysis or new interpretation of historical data. I continue to believe that, on average, smokers are exposed to less smoke when smoking lower yielding products. I also understand others, including members of the government and public health community agree with my view.

B. CIGARETTE DESIGN

Q. Setting aside the question of whether compensation is complete or not for the moment, let's turn to the second criticism you mentioned relating to claims of designing cigarettes to facilitate compensation. Let me ask you about that claim and similar allegations that have been made in this case.

A. Okay.

Q. As a 27 year employee of Reynolds, and someone who worked on cigarette design throughout your career, will you tell the Court whether Reynolds ever had a design objective to facilitate compensation?

A. We have not.

Q. Will you tell the Court whether Reynolds ever had a design objective to increase the "elasticity" of its cigarettes

A. We have not. In fact, "elasticity" is not a term that we use at Reynolds.

Q. Has Reynolds researched ways to limit or prevent compensation by smokers?

A. Yes.

Q. What is some of the research Reynolds has done in this area?

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A. At various times, our scientists have come up with ideas about how to limit compensatory smoking behaviors and we engaged in exploratory research on those ideas. For example, we've looked at critical flow orifices which would limit the amount of smoke that could be drawn through a filter. That idea did not work because we could not overcome the problem of a very high pressure drop. We also looked at a ball valve filter that was intended to block the smoke stream if a smoker puffed too hard on the cigarette. We could not get that type of filter to work on any sort of consistent basis. We've considered a variety of approaches, but all of them have had problems.

Q. Has Reynolds been successful in developing a consumer acceptable cigarette that is "compensation proof"?

A. No.

Q. The Government in this case has introduced exhibits from Reynolds' files regarding a prototype filter described as the multijet [U.S. Exhibit 30,037; U.S. Exhibit 30,086; U.S. Exhibit 87,554; U.S. Exhibit 87,555]. The Government has also elicited testimony regarding the multijet filter from Dr. Farone [Farone written direct, 133:17-134:1] and Dr. Henningfield [Trial testimony, 7536:24–7540:16]. Are you familiar with the multijet filter?

A. Yes. Multijet was one of our project names for what is generally known as a jet impaction filter. There was a lot of interest at Reynolds in this type of filter in the late 1960s and early 1970s.

Q. Was the multijet filter intended to prevent compensation?

A. No. The intent of the multijet was to filter out larger smoke particles with the expectation of reducing the deposition and retention of cigarette smoke.

Q. Did the multijet filter work?

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A. No. There were significant problems with the multijet prototypes. For one thing, the jets would become clogged and therefore would not function effectively after a few puffs. They also caused a high pressure drop and in some versions produced a biting sting to the smoke, two aspects which consumers would not find acceptable. Despite a fair amount of effort, Reynolds could not reduce the jet impaction filter concept to a commercially viable filter.

Q. US 87,554 and 87,555 are two exhibits from 1994 that discuss a multijet impaction filter. Are you familiar with this work?

A. Yes. Jack White, who is referenced in these exhibits, was a Reynolds' scientist who worked on the prior multijet research. In the early 1990s, he theorized that smaller smoke particles would provide enhanced sensory and taste characteristics to smoke as compared to larger smoke particles. The two exhibits are related to that work.

Q. Did Jack White's research have anything to do with preventing compensation?

A. No. It was sensory research, as the exhibits indicate.

Q. Was the multijet filter in any of its iterations a consumer acceptable compensation proof cigarette?

A. No.

Q. From a practical cigarette design perspective, Dr. Townsend, do you know of any proven technique that would prevent a smoker from taking as big a puff as they wanted to?

A. No.

Q. From a practical cigarette design perspective, Dr. Townsend, do you know of any proven technique that would prevent a smoker from taking as many puffs on a cigarette as they wanted to?

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A. No.

Q. From a practical cigarette design perspective, Dr. Townsend, do you know of any proven technique that would prevent a smoker from taking a puff as frequently as they wanted to?

A. No.

Q. From a practical cigarette design perspective, Dr. Townsend, do you know of any proven technique that would prevent a smoker from smoking as many cigarettes as they wanted to?

A. No.

Q. Does Monograph 13, or any other government or public health publication or commentary for that matter, explain how the cigarette manufacturers can make a cigarette that would preclude smoker compensation?

A. No. I am not aware of any.

Q. Dr. Farone testified that Reynolds' Winston Lights are designed to facilitate compensation [Farone written direct, 115:23 – 116:2]. Do you agree?

A. No. We do not design Winston Light, or any of our cigarette brands, to facilitate compensation.

Q. Dr. Farone testified that the cigarette manufacturers make design choices to facilitate nicotine delivery [Farone written direct, 72:7-18]. Does Reynolds make design choices to facilitate nicotine delivery?

A. No, we do not.

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C. SPECIFIC AMES ACTIVITY

Q. The third criticism that you mentioned relates to claims that "light" cigarettes may present increased health risk on a per milligram of tar basis compared to full-flavor cigarettes. Will you explain your understanding of that allegation?

A. Yes. First, it is important to define the comparison that is being made. Assume Cigarette A is a full-flavor cigarette that yields 15 mg of tar by the FTC method and Cigarette B is a light cigarette that yields 10 mg of tar by the FTC method. If tests are run on what is called a "per cigarette basis," then all of the tar from Cigarette A is compared to all of the tar from Cigarette B, in other words 15 mg of tar compared to 10 mg of tar. These tests tend to account for the quantitative difference in yields between cigarettes.

In contrast, tests can be conducted that in essence compare 1 mg of tar from Cigarette A to 1 mg of tar from Cigarette B. Such a comparison is said to be made on a "per milligram basis" or "equal weight of tar basis" and tends to account for the qualitative difference, if any, between an equal amount of tar from both cigarettes. These tests do not account for the quantitative difference in yields, or in other words, for the fact that one cigarette may yield substantially more tar than another.

One recent allegation that has been made is that tests conducted on a per milligram basis suggest that the tar from light cigarettes is more hazardous than the tar from full flavor cigarettes, based on the results of certain Ames mutagenicity tests. Those who make this allegation claim that this is particularly significant because, if compensation is complete, then smokers will be exposed to not only the same amount of tar as the full flavor product, but that the tar to which they are exposed presents even greater risk.

Q. What is your view as to the validity of this criticism?

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A. I do not think that the view that light cigarettes are more hazardous is correct. I think that there are significant problems with extrapolating from the available per milligram testing data to prove a claim that light cigarettes are more hazardous than full flavor cigarettes.

Q. Why do you think the criticism is incorrect?

A. There are several reasons.

First, in my view, the gold standard for determining whether lower tar cigarettes present less risk to smokers is the epidemiology that has been conducted for decades. As I previously testified, and as most everyone agreed up until recently, the epidemiology clearly shows a reduction in lung cancer risk for smokers of lower tar cigarettes compared to higher tar cigarettes.

Second, as I previously testified, based on my work at Reynolds, I believe that compensation is not complete. Therefore, on average, smokers of lower tar cigarettes as a group take in less smoke.

Third, reliance on the Ames mutagenicity test as a definitive measure of human health risk is not legitimate. The Ames mutagenicity test is important, but it is only one assay. Taken in isolation, Ames results are insufficient to make supportable conclusions about human health risk. Put another way, if the only difference between two cigarettes is that one has a statistically significant reduction in Ames mutagenicity, I don't think any scientist would stand up and say that the cigarette with lower Ames activity was in fact safer.

Fourth, another issue with the Ames results is that they are not consistent. We've conducted Ames tests for decades on commercial cigarettes at Reynolds and have published some of this work. Whereas there are numerical differences in Ames results, and sometimes they are statistically significant, it would be incorrect to conclude that lower tar cigarettes are always statistically significantly more mutagenic on a per milligram basis. In fact, if you

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look at all of the data taken together, it shows that there is no statistically significant difference in the Ames results on a per milligram basis for light versus full-flavor cigarettes. Of course, on a per cigarette basis, lights are significantly less mutagenic.

Fifth, you have to look at the weight of the scientific evidence, not just one assay. There are other biological assays besides Ames that can be conducted on a per milligram tar basis. These other tests have shown either no difference in biological activity on a per milligram basis, or less biological activity for the lower tar cigarette. For example, at Reynolds, we use a standardized test called the Neutral Red Assay, which is a measure of cytotoxicity. On a per milligram tar basis, under the Neutral Red Assay, we have seen no difference in per milligram cytoxicity across all of our brands. Although, if you just compare full flavor cigarettes to their light counterparts on a per milligram basis, we did see a statistically significant reduction with many of the lights brands. In addition, the NCI-TWG found that the smoke condensate from cigarettes with filter ventilation had lower tumorigenicity on an equal weight basis in the mouse skin painting tests compared to cigarettes without filter ventilation.

For all of these reasons, I do not think those claims about light cigarettes are correct.

Q. In your opinion, have the design features that Reynolds used in its light cigarettes made the smoke more toxic than that of its full flavor cigarettes?

A. No. I believe that on a per milligram basis, the toxicity of the smokes are similar, but on a per cigarette basis, the light cigarettes have significantly reduced toxicity.

Q. What is your view with respect to whether lower tar cigarettes present less risk than higher tar cigarettes?

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A. I think that the weight of the evidence still supports the conclusion that lower tar cigarettes present less risk than higher tar cigarettes. The historical epidemiology is consistent and strong in support of that conclusion.

X. REBUTTAL OF SPECIFIC GOVERNMENT ALLEGATIONS

A. AIR DILUTION – VENTILATION HOLE PLACEMENT

Q. While we are on lower tar, one of the techniques that you described previously was the use of filter ventilation. And, there have been allegations regarding the extent to which smokers may block ventilation holes. In that regard, Dr. Farone testified that while he was at Philip Morris he did not engage in any type of deception to put ventilation holes in a place where smokers would likely block them [Trial testimony, 1689:3-6]. Did Reynolds?

A. No, we did not.

Q. Why does Reynolds place ventilation holes on filters where they do?

A. With a few exceptions, we typically put ventilation holes about 13 to 15 millimeters from the mouth end of the cigarette. If we put it closer to the mouth end, that would increase the likelihood that it would be blocked by a smoker's lips. If we put it further away from the mouth end, then it diminishes the filter's effectiveness as a general reduction technique.

Q. Why would moving the ventilation holes further away from the mouth end decrease a filter's effectiveness in reducing tar?

A. Recall my earlier testimony. In addition to diluting the smoke stream with air, filter ventilation increases the efficiency of the part of the filter that is upstream of the holes by slowing the velocity of the smoke in that section of the filter. If we move the vent holes further away from the mouth end, then we will decrease that portion of the filter that is very efficient. That would impair our ability to make very low tar cigarettes.

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Q. In this case, Dr. Burns claimed that the size and location of the holes created a turbulence of air flow when the cigarettes were smoked by humans, but a laminar flow when smoked by the FTC machine. And, that somehow that phenomenon made cigarettes more "elastic" [Trial testimony, 13366:7–13368:3]. Do you recall that testimony?

A. Yes.

Q. Do you agree with Dr. Burns' testimony?

A. No.

Q. Why not?

A. Dr. Burns' testimony that there is laminar flow through filter vents under machine puffing conditions, but turbulent flow at more intense puffing conditions, such as those that a smoker may achieve, is incorrect. We have researched the flow dynamics of a cigarette. Turbulent air flow through the vent holes does not occur. Although there is a difference in the flow of air through filter vents versus the tobacco rod, it is not for the reasons Dr. Burns provided, nor does it occur only under more intense puffing conditions. The fact that the proportion of air flowing into a cigarette through the tobacco rod changes during a puff happens both under the FTC smoking parameters and as cigarettes are smoked by humans. I do not understand Dr. Burns' testimony that this phenomenon relates to "elasticity."

B. ALLEGATIONS REGARDING BIOLOGICAL RESEARCH AND THE "GENTLEMEN'S AGREEMENT"

Q. Dr. Townsend, let's switch topics. You have described at various times in your testimony in-house biological tests that have been done by Reynolds on different cigarettes, including commercial cigarettes. Let me ask you, have you ever heard of something called the gentlemen's agreement?

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A. I have heard of it in the course of litigation.

Q. Have you ever seen Reynolds documents that referred to the so-called gentlemen's agreement?

A. Yes, again, in the course of litigation, I have been shown a handful of documents, all of which I think are decades old, that make reference to something called a gentlemen's agreement.

Q. Have you ever heard the claim that because of some so-called gentlemen's agreement, Reynolds isn't supposed to do certain biological testing in-house?

A. I have heard that claim made in litigation.

Q. In your 27 years with Reynolds, has anyone ever told you that you can't do certain research because of some so-called gentlemen's agreement?

A. No.

Q. Has anyone ever told you that you could not perform in-house biological research with intact animals on commercially marketed cigarettes?

A. No. In fact, we've done that research for many years during my tenure.

Q. Has Reynolds conducted research in-house on its commercial products that has indicated biochemical differences in toxicity?

A. Yes, many times.

Q. Has it been your experience that Reynolds has been afraid to conduct research that would generate scientific data showing that one cigarette is likely to be less hazardous than another?

A. No. We've done that testing too.

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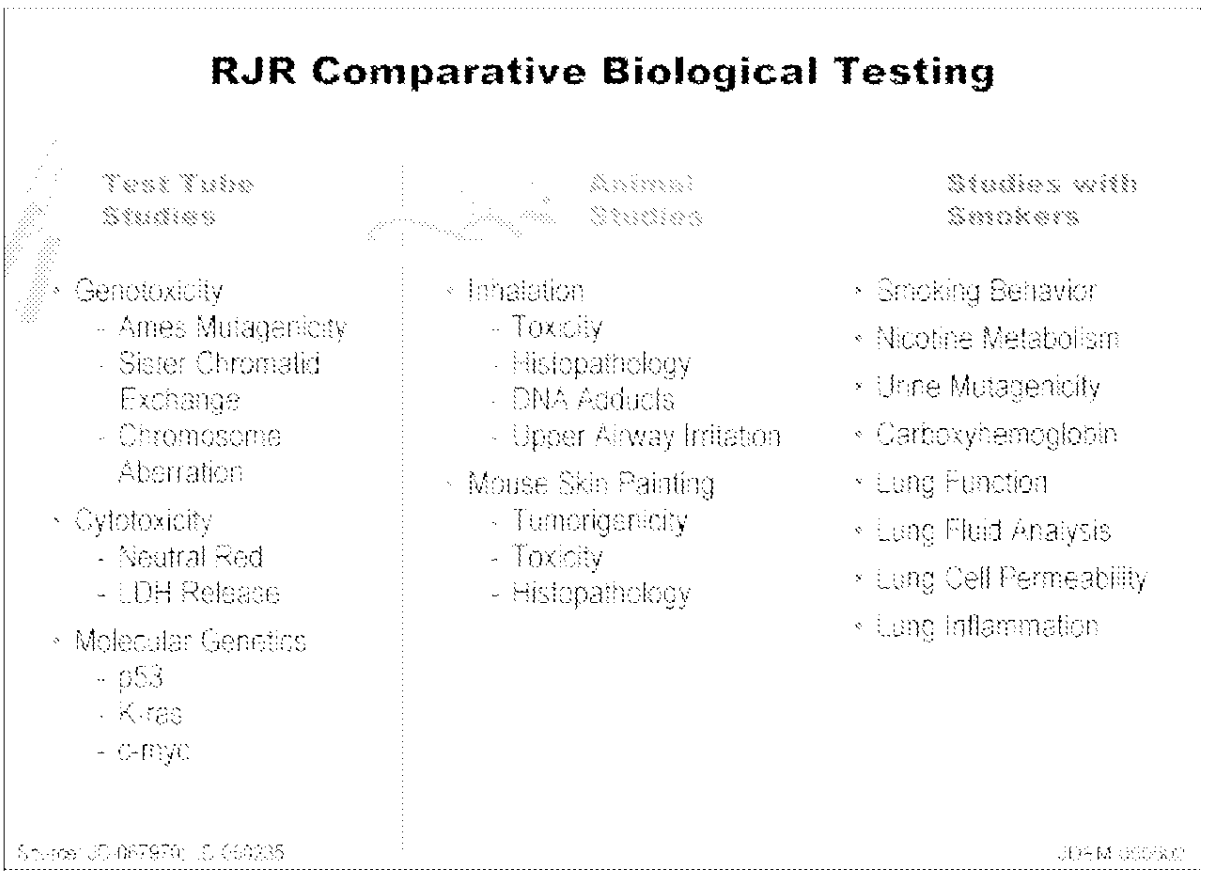
Q. Let's talk about the biological testing Reynolds does. Have you prepared a chart that will assist you in explaining the types of biological testing conducted by Reynolds?

A. Yes.



Q. With reference to your chart, please tell the Court about the comparative biological tests that Reynolds has used during your tenure.

A. On the left-hand side of the chart are the test tube studies - the *in vitro* type toxicology and biology that we've already talked about. The test tube studies that Reynolds has used are toxicity measures including Ames mutagenicity, sister chromatid exchange, chromosome aberrations. These are all standard toxicology assays. In the area of cytotoxicity, which is toxicity to cells, neutral red is the primary measure that we use

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internally. LDH release is another test that we've used, although mainly through contract laboratories. Using molecular techniques, we have looked at the cancer-related genes P53, K-ras, and c-myc.

In the middle of the chart are the animal studies, including inhalation studies, histopathology, DNA adducts from animals exposed to smoke, as well as upper airway irritation in rodents. Mouse skin painting is another routine experimental technique at Reynolds in which we look at mouse skin tumorigenicity. We also look at toxicity and histopathology of the animals that are exposed.

Finally, on the right hand side of the chart, are studies with human smokers. This is a very important and growing area in smoking and health research, and, in particular, trying to understand smoking behavior, how nicotine is metabolized in the body and what nicotine exposure levels are. Urine mutagenicity, a measure of exposure to compounds capable of mutating DNA, is an important measure that we make. Carboxyhemoglobin testing measures exposure to carbon monoxide. Additionally, we use lung function tests, lung fluid analysis, and lung cell permeability testing. Evaluation of lung inflammation is another very important test of which we've conducted a lot of research by contract where we actually look at lung cells in human smokers and measure the degree of inflammation of those cells and then have them smoke different products to see if there are differences in the degree of lung inflammation. Another area of study with smokers is biomarkers of exposure. That's an area that's just really starting to mushroom. We have done a lot at Reynolds in developing new analytical methods to measure biomarkers of smoke exposure. For example, we've talked in this testimony about polycyclic aromatic hydrocarbons. We're developing a marker now that can estimate what the exposure of a particular human subject is to polycyclic aromatic

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hydrocarbons. In the case of aldehydes, we can measure from blood analysis or from urine analysis what the exposure is to aldehydes when a person smokes.

Q. Does Reynolds do all of those tests in-house?

A. With the exception of the lung studies with smokers, we have done all of those tests in house. Some of them we do in house very routinely, especially the genotoxicity and cytotoxicity. We are continuing some research in molecular genetics. We routinely conduct animal inhalation and skin painting studies. And we routinely are measuring biomarkers of exposure, carboxyhemoglobin, and smoking behavior. But, we rely on medical organizations to conduct the tests with smokers regarding lung function, lung inflammation and the like.

Q. Does Reynolds conduct those tests on commercial cigarettes, on ones that are actually sold that people can buy and smoke?

A. Yes, we conduct them on commercial cigarettes, as well as experimental prototypes that we're developing that might pose less risk.

Q. And do you study competitors' cigarettes?

A. Yes.

Q. What does the information gained from Reynolds' biological testing mean to you as a cigarette designer when you're looking at how to design a cigarette?

A. In designing a cigarette, one of our overall objectives is to reduce risk. Thus these biological assays can tell us whether we're making progress, particularly if one does a considerable amount of experimentation across the full breadth of possible testing and then looks at the weight of evidence. If there are big changes in *in vitro* biology and in *in vivo* biology and there are also certain changes seen with human smokers, there is a significant weight of evidence that you're meeting your design objective of reducing risk.

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C. RECONSTITUTED TOBACCO SHEET – AMMONIA AND NICOTINE MANIPULATION

Q. Let's move on. Another allegation that has been made in this case relates to nicotine manipulation and reconstituted tobacco sheet. Does Reynolds add any nicotine to reconstituted tobacco used in its commercial cigarettes?

A. No, as I testified, we reapply what was removed, but we do not add nicotine.

Q. Has Reynolds ever done so in commercial cigarettes?

A. No, we have not.

Q. Does Reynolds use reconstituted tobacco as a blend component to fine tune the nicotine levels of its cigarettes?

A. No.

D. NICOTINE MANIPULATION: AMMONIA AND SMOKE PH

Q. There have also been allegations in this case about ammonia and smoke pH. Has Reynolds used ammonia in the reconstituted tobacco sheet process?

A. We use a low amount of ammonia compounds in the manufacturing process for some, but not all, types of the reconstituted tobacco we make. Typically, we've used diammonium phosphate in the reconstituted sheet. There are a couple brands where we've used a compound called urea, which is a ammonia-containing compound. And then there was a case a number of years ago, in which we used a reconstituted tobacco sheet where we added gaseous ammonia.

However, in other brands we use reconstituted tobacco sheet without ammonia.

Q. Why does Reynolds use ammonia in certain types of reconstituted tobacco?

A. It turns out that if one adds ammonia at certain levels and in certain types of processing, like in reconstituted tobacco, you can improve the taste characteristics of that tobacco. A secondary reason is that you will see some increase in the tensile strength of the

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reconstituted tobacco sheet with the addition of ammonia. However as a cigarette designer, I think the most important reason for using ammonia is for the taste characteristics. Ammonia reacts with certain sugars that are naturally present in the tobacco to form a class of compounds that are called pyrazines. Those pyrazines are extremely flavorful, extremely powerful flavors that are also found in such things as chocolate and coffee.

Q. Why doesn't Reynolds use ammonia in all of its reconstituted tobaccos?

A. We found that ammonia affects the taste characteristics of the cigarettes, but only some smokers like that different taste. That is why we offer some products with ammonia and some without.

Q. In addition to its effect on flavor, did any scientists at Reynolds suggest researching ammonia for reasons other than for the purpose of improving taste?

A. Yes. Some Reynolds scientists, like Claude Teague, theorized that ammonia processing would have an effect on smoke pH.

Q. Are you familiar with claims that smoke pH could affect the amount of free nicotine in smoke?

A. Yes.

Q. What is free nicotine?

A. Nicotine has two nitrogen molecules on it and is considered, on the pH scale, to be a basic compound. Basic compounds can react with acids, pick up a hydrogen ion, and become a salt. The salt, or bound, form of nicotine is really not volatile, whereas free nicotine, without picking up a hydrogen ion, is actually a semi-volatile. So, free nicotine can evaporate while the bound/salt version is not volatile.

Q. Is this free nicotine theory a secret?

A. No.

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Q. Have scientists at Reynolds discussed the possible relationship of smoke pH and free nicotine?

A. Yes.

Q. Was the issue of pH and free nicotine discussed in the publicly available literature?

A. Yes.

Q. Let me show you JD-040395 and ask you to identify it.

A. This is a published article from 1972 by Dr. Gerald Morie, of Tennessee Eastman, entitled "Research Note: Fraction of Protonated and Unprotonated Nicotine in Tobacco Smoke at Various pH Values."

Q. Do your rely upon this article for information about smoke pH?

A. Yes.

Q. What does this article in 1972 report on the pH of domestic blend cigarettes?

A. Dr. Morie reports that the smoke pH of domestic blend cigarettes ranges from 5.2 to 6.2. He goes on to say, "It is obvious from this that the percentage of unprotonated nicotine in the TPM of smoke from these cigarettes is very low (.22 to 2.17 percent)."

Q. Do you agree with that assessment?

A. Yes.

Q. Let me show you JD-000735 and ask you to identify it.

A. This is a published article from 1974 by Drs. Brunnemann and Hoffmann, of the American Health Foundation, entitled, "The pH of Tobacco Smoke."

Q. Do you rely on this article for information about smoke pH?

A. Yes.

Q. What do Drs. Brunnemann and Hoffmann report about smoke pH?

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A. At that second sentence up at the top of page 122, they report: "Cigarettes made from Bright tobacco or blended tobacco deliver mainstream smoke below a pH of 6.2 and consequently contain only small amounts of unprotonated nicotine."

A. Yes.

Q. Do you agree with that assessment?

A. Yes.

Q. Have there been recommendations from the public health community about altering smoke pH as a possible means to reduce risk?

A. Yes.

Q. Let me show you JD-000753 and ask you to identify it.

A. This is an article published in the Journal of the National Cancer Institute from 1974 by Dr. Elson and Mr. Betts entitled, "Sugar Content of the Tobacco and pH of the Smoke in Relation to Lung Cancer Risks of Cigarette Smoking."

Q. Do you rely on this article for information about smoke pH and potential additives?

A. Yes.

Q. What do Dr. Elson and Mr. Betts say about the use of ammonia compounds, smoke pH and the risks of smoking?

A. On page 1888 of their article, they state: "... [W]hat then are the implications for a less harmful cigarette? Apart from replacing flue-cured tobacco by air-cured, low sugar tobacco, which in the form of cigarettes probably would not be readily acceptable to the majority of the smoking public, one suggestion would be to raise the pH of the smoke of cigarettes containing flue-cured tobacco. One way to accomplish this would be by additives that would give rise to an alkaline vapor at the usual temperature of combustion of cigarettes.

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Elson, et al., [citation omitted] found that the addition of 4% urea to flue-cured cigarettes containing 18% sugar reduced the acidity and reversed the character of the smoke so that it become progressively less acid during smoking."

Q. To be clear, what is your interpretation of what Dr. Elson is recommending?

A. Several things. One, he recognizes the importance of consumer acceptability when you are considering modifying cigarettes. Two, he suggests that additives could be used to raise smoke pH. Three, he specifically discusses the use of urea, an ammonia compound, as one possible way to accomplish in increase in smoke pH.

Q. You mentioned that Reynolds' scientists have discussed the issue of smoke pH and ammonia. Did some of these scientists theorize that ammonia could be added to cigarettes to raise smoke pH and increase the amount of free nicotine?

A. Yes, some did.

Q. And, as a scientific theory, does it make sense to you?

A. Yes, in theory, if you use enough ammonia, or ammonia compounds, you should be able to increase smoke pH.

Q. Have you gone back and personally looked at the smoke pH levels of some of the brands of cigarettes that Reynolds sells and looked for the effect that Reynolds' ammonia usage may have had, if any?

A. Yes, I have.

Q. What did you find?

A. What I found was that at the levels of ammonia we add to cigarettes, the smoke pH doesn't change. An example of this is when we first ammoniated Camel in 1974. The pH before we added ammonia was about six, and the pH after we added ammonia was also six.

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Winston is another example. We first ammoniated Winston in 1979. The pH before we ammoniated was the same as the pH after we ammoniated. Then in 1997, we took all tobacco additives out of Winston, including ammonia. Before 1997, Winston had a smoke pH of about six and after we took all of the additives out, the smoke pH was still about six.

Q. In this case, Dr. Farone testified that he looked at Reynolds' smoke pH data for its Winston and Now brands and believed that it showed that Reynolds did increase smoke pH over time, and as tar decreased [Farone written direct, 98:2-8]. Do you agree with Dr. Farone?

A. No.

Q. Why not?

A. For several reasons, and in part, because of the testimony I just provided. Winston's tar yield has decreased over time and yet its smoke pH has remained at about six. In addition, whereas some of our ultra light cigarette brands style, such as certain versions of our Now cigarette, have a slightly higher smoke pH, other versions of Now at the same tar level do not have a higher pH. To suggest that smoke pH increases as tar decreases is simply incorrect. Are there measurable differences in smoke pH? Yes, but there is no general trend and we certainly do not implement design techniques into our cigarettes, including our very low tar cigarettes, with the intent of affecting smoke pH. All of our cigarettes have a smoke pH of about six.

Q. At a pH of six, how much free nicotine is there, if any, in the smoke from the cigarettes that Reynolds sells?

A. Very little. Using a calculation from an equation called the Henderson-Hasselbach equation, one can actually estimate how much free nicotine there should be. It estimates the

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free nicotine from the acid-base equilibrium, and the answer is extremely small amounts of free nicotine would be expected at a pH of six using that calculation.

Q. Has the U.S. Surgeon General also spoken about the amount of free nicotine expected in cigarette smoke?

A. Yes, in the 1979 Surgeon General's Report.

Q. Let me show you page 14-108 from U.S. Exhibit 64,071, the 1979 Surgeon General's Report which has already been admitted into evidence. Please read what the Surgeon General says about smoke pH and free nicotine.

A. "Since cigarettes in the United States and in most foreign countries are made of flue-cured tobacco, are blends with flue-cured tobacco as a major ingredient or, in a few cases, are blends with Turkish tobacco, the pH of the resulting mainstream smoke is below 6.5 and thus essentially contains only protonated nicotine."

Q. What is protonated nicotine?

A. Protonated nicotine is the same as bound nicotine.

Q. Do you agree with what the Surgeon General says in the 1979 Report about smoke pH and the amount of free nicotine in U.S. cigarettes?

A. Yes, in general.

Q. Before moving on, I have a few additional questions about smoke pH and ammonia. First, are you familiar with the claim that there is a correlation between smoke pH and cigarette sales, such that cigarettes with higher smoke pH sell better?

A. Yes, I am aware of that claim. Frankly, some Reynolds scientists in the early 1970s suggested that and actually performed some statistical analysis that they believed supported their theory. I am aware that Reynolds' documents regarding this issue have been admitted into evidence in this case as U.S. Exhibit 20,669 and U.S. Exhibit 20,840.

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Q. Have you looked at the merits of the theory that there is a correlation between smoke pH and cigarette sales?

A. Yes, I have.

Q. What is your view of that theory?

A. It is not a valid theory. In the early 1970s, it appeared that way, but when you look at all of the data, it just hasn't held up. One can look at the smoke pH values for cigarettes, compare that to their market share and quickly see that there is no correlation. Smoke pH does not correlate with sales.

Q. I have one other question about ammonia. Does ammonia, or ammonia-containing compounds, as used by Reynolds extract nicotine from the tobacco in a cigarette during smoking, as the smoke travels down the cigarette rod?

A. No. That is a theory that I've heard Dr. Farone espouse in litigation as a supposed way that the manufacturers artificially increase nicotine yields. Not only do we not use ammonia for that purpose, but I have never seen data demonstrating that theory to be true.

In fact, I think that theory is wrong. Given that nicotine resides inside the cellular structure of tobacco, it is highly unlikely that ammonia would extract the nicotine. In addition, if you compare cigarettes with and without ammonia, there is no difference in nicotine yield.

E. SMOKE PARTICLE SIZE

Q. Let's turn to another allegation. Do you recall Dr. Farone testifying regarding smoke particle size [Farone written direct, 50:20–52:4; 58:20–60:2; 91:12–93:4]?

A. Yes. I specifically recall Dr. Farone testifying that changing tobacco cut width changed smoke particle size.

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Q. Does Reynolds somehow control the actual size of the particles that are in the smoke?

A. No, that's absolutely false. We do not control the particle size, nor do we have a way of doing it even if we wanted to.

Q. What's the basis for your opinion in that regard?

A. Cigarette smoke is what scientists call a condensation aerosol. A condensation aerosol typically forms particle sizes in a fairly narrow range, in the submicron range. For cigarette smoke, it's around two-tenths of a micron on average, which is really very small. Any changes to the cigarette at most will cause small and really not meaningful changes to any measured particle size.

Q. Do you agree with Dr. Farone's view regarding tobacco cut width?

A. No.

Q. Why not?

A. There are several reasons. First, as someone who worked at Reynolds for over 27 years, I can tell you that we did not alter tobacco cut width to affect smoke particle size.

In addition, as I said, cigarette smoke particle size is in the submicron range. Respirable particles are generally considered to be in the range of under 7 to 10 microns. There is at least an order of magnitude difference between cigarette smoke and the upper respirable limit. Any change in tobacco cut width is not going to shift the smoke particle size outside of this respirable range.

In order to have a significant effect on smoke particle size, there would have to be dramatic changes in the design of the cigarette, something that Reynolds does not do.

Q. Does tobacco cut width affect the FTC machine's ability to accurately measure smoke nicotine yield?

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A. No. The FTC protocol captures all mainstream nicotine, so even if cut width did affect nicotine yield, it would be picked up by the FTC test.

That said, there is no data of which I'm aware that shows that a difference in tobacco cut width affects nicotine yield. As I've previously testified, Reynolds has researched many, many general reduction techniques to reduce tar and nicotine. Tobacco cut width simply is not a parameter that is used to alter smoke yields, nor can it be to any meaningful extent. In that regard, there is no difference in the cut width of our tobacco across our cigarettes brands and brand styles, from full-flavor to ultra light.

Q. While we are on the subject of cut width, do you recall Dr. Burns' testimony in which he claimed, among other things, that the cigarette manufacturers engineered the size of the reconstituted tobacco sheet that they use in cigarettes in order to affect the burn rate of cigarettes, thereby creating an "elasticity" of yield [Trial testimony, 13366:7–13368:3]?

A. I remember that testimony.

Q. Do you agree with Dr. Burns' testimony regarding the cut width of reconstituted tobacco sheet?

A. No.

Q. Why not?

A. Reconstituted tobacco sheet cut width is not a design technique that we use to affect cigarette burn rate. Reconstituted tobacco is cut at the same time as the tobacco lamina we use and therefore has the same cut width. In addition, burn rate is a factor in how much of the tobacco rod is consumed during smolder, but it is not important to how much smoke is generated during puffing. Rather, the amount of smoke generated is determined by the volume of air that is available during a puff. This is true regardless of whether the cigarette

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is smoked by a machine or by a person. I do not understand how this phenomenon is related to "elasticity."

Q. Dr. Henningfield suggested in this case that filters and moisture content could somehow affect particle size [Henningfield written direct, 43:15-45:22; Trial testimony, 7333:21–7340:2]. Does Reynolds use filters or control moisture content to affect particle size?

A. We use filters and we do control the moisture content in the tobacco. But neither of those affect the particle size of the smoke that comes out of that cigarette in any meaningful way. There have been studies, including those published by Reynolds' scientists, that have shown no difference in smoke particle size for filtered versus unfiltered cigarettes, and for cigarettes with varying degrees of filter ventilation.

Q. Just to be clear, does R.J. Reynolds do anything to its cigarettes with the intent of affecting the size of smoke particles?

A. No, we don't.

Q. Dr. Henningfield also testified that Reynolds carefully engineered the particle size of Premier's smoke and he relied on Reynolds' testing for his view [Trial testimony, 7340:3 – 7341:24]. Did Reynolds test the particle size of Premier's smoke?

A. Yes.

Q. Was that done so that Reynolds could engineer the smoke particle size of Premier?

A. No.

Q. Then why was particle size measured?

A. We measured the smoke particle size of Premier's smoke in the animal inhalation studies we conducted as a method of quality control. Measuring the particle size of aerosols

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in any animal inhalation study is standard procedure in the scientific community and is not unique to Reynolds, or cigarette smoke. By measuring particle size, we can insure that the animals are being exposed to the same smoke. As smoke ages, its particle size changes significantly. If we determine that the animals are exposed to smoke of the same particle size, then we can be confident that the animals are being exposed to the same smoke of the same age. So, it is a quality control mechanism.

Q. How did that particle size data affect Reynolds' design efforts with respect to Premier?

A. Not at all. We did not use that data to engineer Premier's smoke.

F. CRITICISMS OF REDUCING THE TAR-TO-NICOTINE RATIO

Q. You previously testified regarding Reynolds attempts to change the T/N ratio. Are you familiar with criticisms of Reynolds' research in that area?

A. Yes, I am.

Q. Are you familiar with claims of nicotine manipulation with respect to that research?

A. Yes.

Q. What is your opinion as to the merits of those criticisms of Reynolds' research?

A. Frankly, I think those claims are just off-base. For decades, scientists and public health officials with no connection to the cigarette manufacturers have suggested changing the T/N ratio as a possible way to make a safer cigarette. We were certainly aware of those suggestions. As with all reasonable suggestions, we've taken it seriously and have tried to see if we could accomplish it in a consumer acceptable fashion. To criticize that research, especially considering that we've not implemented those technologies into our commercial cigarettes, is just an unfair distortion of what we were trying to accomplish.

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Q. Let me follow up on that. You testified that recommendations for reducing the T/N ratio had been made publicly since the early 1970s. Were scientists from Reynolds discussing those recommendations at the time they were being made?

A. Yes.

Q. Including a scientist from Reynolds named Claude Teague?

A. Yes.

Q. The Court has seen some documents by Dr. Teague. Do you personally know Claude Teague?

A. Yes, I know Dr. Teague, although I have not seen him in many years.

Q. Did he work at Reynolds while you were there?

A. Yes, we had several years of overlap.

Q. Is Dr. Teague still with Reynolds?

A. No, he retired in the late 1980s.

Q. What was Dr. Teague's educational background?

A. He was an organic chemist by training. In the late 1960s, he also took some courses at the MBA school at University of North Carolina-Chapel Hill.

Q. During Dr. Teague's career at Reynolds, was he ever the Executive Vice President of Research and Development, like you?

A. No.

Q. Was Dr. Teague ever a Vice President of any department at Reynolds?

A. No.

Q. Was Dr. Teague ever in charge of product development at Reynolds at any point in his career?

A. No, he never worked in product development.

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Q. Did Dr. Teague work on the design of cigarettes while you were at Reynolds?

A. No, he's never been involved in cigarette design; he's never been a product developer.

Q. To your knowledge, did he ever set any policy as to what type of nicotine research Reynolds could do?

A. No, he didn't.

Q. And if Dr. Teague said, "I've got a good idea, we should do this type of research," does that mean it would get done?

A. No. Just because Dr. Teague wrote it down, did not mean that it was done.

Q. Based on your knowledge of historical Reynolds documents, did Claude Teague ever actually conduct research on nicotine?

A. No.

Q. Did he ever do animal testing with nicotine?

A. No.

Q. Did he ever do human testing with nicotine?

A. No.

Q. Let me ask you some questions about an exhibit that the Government has admitted into evidence in this case from Dr. Teague and has been referred to by the Government in its opening statement, and was cited by Dr. Kessler, Dr. Farone, and Dr. Henningfield in their testimony. It is U.S. Exhibit 20,659, entitled "Research Planning Memorandum On The Nature Of The Tobacco Business And The Crucial Role Of Nicotine Therein." On page 3, Dr. Teague says: "If nicotine is the sine qua non of tobacco products and tobacco products are recognized as being attractive dosage forms of nicotine, then it is logical to design our products -- and where possible, our

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advertising -- around nicotine delivery rather than 'tar' delivery or flavor." First of all, what does sine qua non mean?

A. I'm not a Latin scholar, but I would translate that as "without which nothing," meaning that it is essential.

Q. Is there anything about that sentence that fits in with any policy that Reynolds has had in its history?

A. No, I'm not aware of any policy that squares with Dr. Teague's theory.

Q. Dr. Teague suggests that Reynolds should "design our products -- and where possible, our advertising -- around nicotine delivery rather than 'tar' delivery or flavor." Did Reynolds ever follow his suggestions about designing and advertising around nicotine, instead of tar or flavor?

A. No.

Q. Moving to page 4 of U.S. Exhibit 20,659, it says: "In the absence of such data, we may survey the market and conclude that the current cigarette products delivering about 1.3 mg. of nicotine appear to 'satisfy' the typical smoker. This, somewhat crudely, establishes a target dosage level for design of new products." As someone who's worked in the design of new products for 25 years, does Reynolds design its new products with a target level of nicotine?

A. No, we don't design to a target nicotine level.

Q. What do you design to?

A. We design to a particular tar level, which would put it in a category of full flavor, lights, ultra lights or even lowest. But tar is a target design criterion. Taste characteristics can be design criteria, but nicotine is not.

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Q. Are you saying that Reynolds doesn't care how much nicotine is in the cigarettes they sell?

A. No. It turns out that in practice for a given tar level, the nicotine level has to be within a certain fairly narrow range to be consumer acceptable. So it is important. It's just that we don't use nicotine design targets in our commercial cigarettes. As I've already testified, when trying to develop reduced T/N ratio cigarettes, we certainly had the objective for a particular nicotine yield, but those were laboratory efforts, not commercial cigarettes.

Q. U.S. Exhibit 20,659 was written in 1972. Since 1972, have most Reynolds products yielded 1.3 milligrams of nicotine or above, as Dr. Teague suggested?

A. No, they're generally lower than that, with many being much lower than 1.3 milligrams. We offer a range of products, with nicotine yields down to 0.1 milligrams or even lower.

Q. On page 6 of Dr. Teague's memo, he says "Our critics have lumped 'tar' and nicotine together in their allegations about health hazards, perhaps because 'tar' and nicotine are generated together in varying proportions when tobacco is smoked. An accompanying Research Planning Memorandum suggests an approach to reducing the amount of 'tar' in cigarette smoke per unit of nicotine. That is probably the most realistic approach in today's market for conventional cigarette products." How does this suggestion compare to what you've testified about regarding reduced T/N ratio cigarettes?

A. It is the same suggestion.

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G. R.J. REYNOLDS' PRODUCT STEWARDSHIP PROGRAM

Q. Let's switch topics. Another allegation in this case has centered around product testing. When Dr. Gentry testified at trial in October, he was asked some questions about "product stewardship." Does Reynolds have a Product Stewardship Program?

A. Yes.

Q. As background, what is Reynolds' Product Stewardship Program?

A. We have a very specific product stewardship philosophy at Reynolds, and it is that in the course of our work, we will make no changes to our cigarettes that will increase the inherent health risks of smoking. It is a very simple and straightforward philosophy.

Q. What do you mean by "in the course of our work"; what aspects of Reynolds' work are subject to the Product Stewardship Program?

A. Reynolds uses this program to evaluate the tobacco leaf we purchase from farmers, our manufacturing processes, the tobacco we have in storage, the cigarette ingredients we use, any proposed product or process modification, and our finished cigarettes.

Q. Please describe Reynolds' Product Stewardship Program.

A. We use a tiered testing program to evaluate potential changes to our products. The first thing we will do is look at the scientific literature to determine what it says, if anything, about the change we're considering. Depending on what the literature review turns up, we will do chemistry testing to see how, if at all, the change affects smoke chemistry. Depending on the results of the chemistry tests, we may conduct short term biological testing. Depending on those results, we may do longer term and more complex biological testing, including tests with animals. Depending on those results, we may conduct smoking behavior tests. Finally, we may seek external review by expert toxicologists. So, it is a step-wise approach and the number of steps we take depends on the nature of the change and the

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results of the testing that we do conduct. We will take as many steps as are necessary so that we can assure ourselves that no change that is made will increase the risks of smoking.

H. CIGARETTE INGREDIENTS

Q. Let's provide an example of how product stewardship works at Reynolds. Are you aware of criticisms regarding the use of cigarette ingredients by Reynolds and its competitors?

A. Yes I am.

Q. Can you tell the Court why Reynolds and other cigarette manufacturers would use additives in some of the cigarettes they sell?

A. Smokers have different and wide ranging taste preferences. There are tens of millions of smokers and they all do not like the same thing. In addition, there are hundreds of brands of cigarettes from which consumers choose. Additives are one way to change the taste characteristics of cigarettes, so that we can differentiate our brands from those of our competitors. We use additives to try to generate different taste signatures, so that, for example, Camel will taste different than Marlboro and, hopefully, smokers will choose our brands over our competitors.

Q. Does Reynolds use additives to make the smoke from its cigarettes more inhalable?

A. No, we do not. I'm not aware of any test that Reynolds has ever done to assess whether additives increase the inhalability of cigarette smoke. Cigarette smoke is inhalable. I'm not aware of any project objective to make one of our cigarettes more inhalable. At various points in this examination, I've referred to Reynolds' removal of tobacco additives from Winston in 1997. I know that we did not conduct any experiments to compare the degree of inhalability between Winston with additives and Winston without additives. To

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my understanding and personal experience, Winston without additives is just as inhalable as Winston with additives.

Q. Dr. Farone suggested that additives, such as sugars, increase the yields of aldehydes in cigarette smoke [Farone written direct, 64:15-20]. Does Reynolds' use of additives, such as sugars, increase the yields of aldehydes?

A. No. One reason why I say that is after we removed all tobacco additives from our Winston brands in 1997, there was no statistically significant difference in aldehyde yields with that change. That is a pretty clear indication that the additives used by Reynolds, including sugars, do not affect aldehyde yields in commercial cigarettes.

Q. Does Reynolds test the additives that it uses in its cigarettes?

A. Yes, we do test all additives that we use in cigarettes. We do it ourselves in-house and also contract some work outside of Reynolds.

Q. Have the additives that Reynolds uses ever been evaluated by independent outside scientists?

A. Yes, they have.

Q. Let me show you JD-000449. Dr. Townsend, please identify this document.

A. This is a 1994 toxicological assessment of the additives used by the major domestic cigarette manufacturers, including the defendant manufacturers in this case.

Q. What was the purpose of the toxicological assessment?

A. In 1994, the manufacturers retained a group of prominent toxicologists to look at each of the additives used to determine whether or not they presented health risks.

Q. Were the prominent toxicologists employees of R.J. Reynolds or the other tobacco companies?

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A. No, they were not tobacco company employees. They were well known toxicologists primarily from universities and medical schools. They were paid for their time to evaluate the additives, of course, but they were asked to form an independent opinion of the health risks.

Q. How was the toxicological review undertaken?

A. As described on page 3 of JD-000449, "The authors of this report, whose qualifications are summarized in the appendix, each independently reviewed the scientific data on ingredients added to cigarette tobacco by the six major United States manufacturers. This report represents their consensus on the safety of the ingredients. The material examined was extensive, and included the confidential list of the ingredients added to tobacco in the manufacture of cigarettes. The authors were also provided with summary data of all relevant published and unpublished toxicity tests and reports, as well as the original publications of data when requested. Pyrolysis and transfer rate data, maximum use levels, and annual poundage data for the ingredients were also evaluated. Each scientist independently visited the individual tobacco companies to examine the testing and research programs used for the ingredients. Reports and raw data from the studies were made available and were examined as necessary and each scientist formed an independent opinion regarding the adequacy of the testing and safety of each ingredient."

Q. What was the conclusion of these outside toxicologists as to the health hazard, if any, of these cigarette ingredients?

A. As shown on the eighth page of JD-000449, the conclusion from this toxicology panel was that the additives and ingredients are "not hazardous under the conditions of use."

Q. Let me now show you JD-000450 and ask you to identify it.

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A. This is a report from 1998 by the same group of toxicologists who were again asked by the manufacturers to go back and evaluate the additives that were in use. This was part of a continuing evaluation of additives by this outside toxicology panel.

Q. Compared to their 1994 evaluation, how was this review undertaken?

A. It was essentially identical in terms of the process that they used. Because it was done several years later, there were some differences in the additives that they evaluated, but the process they undertook was the same as that described in the 1994 review.

Q. What was the conclusion of these outside toxicologists as to the health hazard, if any, of these cigarette ingredients?

A. They reached the same conclusion as before: the additives used are not harmful under the conditions of use.

Q. What testing does Reynolds do on its own with respect to additives?

A. We do extensive testing, including biological testing and pyrolysis testing. We actually heat the additive, break it down into the various components that may occur or be generated during the burning of the cigarette, chemically analyze those components so that we know what its chemistry is under those pyrolysis conditions, and then evaluate from the literature and from the laboratory, those additives and decomposition products to make sure that nothing that we've added to the cigarette will increase the risk.

Q. Has Reynolds reached any type of conclusion with respect to the testing and evaluation of the additives or ingredients in cigarettes that it uses?

A. The additives and ingredients we use don't increase the risk of smoking.

Q. Would a cigarette that had no additives at all be a safe cigarette or even a safer cigarette?

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A. No, I do not believe that additives affect the inherent health risks of smoking. In fact, when we changed the entire Winston brand family to a no-tobacco-additive cigarette, we did a considerable amount of chemical and biological testing. We found no difference in the biological testing when comparing the older Winston with additives to the newer Winston with no additives.

Q. What do you mean when you say you found no difference in the biology?

A. In comparing all of the biological data, we saw no difference in the results from those biological assays, which included mouse skin painting, animal inhalation studies, as well as cytotoxicity and other *in vitro* tests.

Q. Now, before Reynolds and the other manufacturers publicly disclosed the ingredients in 1994, were the companies required to disclose their ingredients to the U.S. government?

A. Yes. By statute, since the mid-1980s, the tobacco companies have been required to submit annually the list of its ingredients to the U.S. government's Department of Health and Human Services.

Q. What is the Department of Health and Human Services supposed to do with the ingredients list that Reynolds and the other manufacturers provide to the government?

A. Under the law, the Department of Health and Human Services is supposed to review this list, and if they see anything on there that causes them concern, they are supposed to notify Congress.

Q. Has Health and Human Services ever made a finding at any time since they have been requiring the ingredients to be reported that any of the ingredients or additives in cigarettes are dangerous?

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A. No, they have never indicated a problem with any of the ingredients on the full additives list.

Q. And are Reynolds and its competitors today still required to submit their ingredients lists to the Department of Health and Human Services?

A. Yes.

Q. Does Reynolds disclose the additives that it uses in any other ways?

A. Yes, on our corporate website.

I. R.J. REYNOLDS' DOCUMENT RETENTION POLICY

Q. I want to switch topics again. There have been allegations in this case regarding certain conduct and internal policies of the cigarette manufacturers, and I want to focus on Reynolds. Does Reynolds have any sort of policy restricting the access by its scientists to certain types of research, such as research into smoking and health issues or biological research on commercial cigarettes?

A. No, there is no such policy. Because we are in a competitive business, we do take precautions in terms of access and dissemination of proprietary and trade secret information. But, there is no policy, nor have I ever heard of a policy, such that our scientists could not access the results of our research, especially research into smoking and health issues or on commercial cigarettes. That information is available to our scientists and I believe it always has been.

Q. Does Reynolds have a policy about retaining research reports and laboratory notebooks?

A. Yes.

Q. What is the policy?

A. It is Reynolds' policy that all research reports and notebooks are retained.

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Q. How long has that policy been in effect?

A. The policy has been in effect since the beginning of the R&D library in the 1950s.

Q. In addition to retaining hard copies of the research reports and lab notebooks, did Reynolds take other steps to ensure that its documents would be available?

A. Yes.

Q. What did Reynolds do?

A. Reynolds implemented a policy in the late 1960s of duplicating the research reports, research memoranda and laboratory notebooks on microfilm. Many of the microfilms are stored in a separate location away from the original in case there is a fire or some other calamity. More recently, we have switched to using computers to manage the documents maintained by the library.

Q. By virtue of the document retention policy and the microfilming, have you been able to obtain copies of Reynolds' research reports and laboratory notebooks from the 1950s through the 1970s, when you joined Reynolds?

A. Yes.

Q. Does Reynolds ever destroy copies of documents?

A. Yes.

Q. Under what circumstances are copies of documents destroyed?

A. As I testified, original research reports and research memoranda are kept in our R&D library. In addition, hard copies of those documents are distributed when the report or memorandum is issued. Also, other scientists may obtain hard copies of the documents from the library by request. Because the R&D library maintains the original, and either a microfilm or electronic backup copy, there is no need for the scientists who received or

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obtained copies of the document to keep it once they are done with it. In those circumstances, it is permissible for the scientists to discard their copy of the document.

Q. Dr. Townsend, is there any means by which you can tell if the original and all copies of a research report from the 1950s or 1960s had been destroyed?

A. Yes.

Q. Please describe that for the Court.

A. At Reynolds, we employed a dual ledger system. Before a scientist began writing a report, a tentative title, the author, and a report number are entered into one column of the dual ledger in ink by hand. Once the report is finalized and submitted to the R&D library, another notation is entered into the second column of the dual ledger in ink by hand. One can then systematically check the entries in the dual ledger to confirm that the reports are in the library. There is no way to destroy or get rid of a document without having an inconsistency with the dual ledger.

Q. Have you personally made any effort to determine if there are any inconsistencies between the dual ledger and reports in the R&D library?

A. Yes.

Q. Did you find any inconsistencies?

A. No.

J. SCIENTIFIC FREEDOM

Q. Let me ask you about other Reynolds' policies. At Reynolds, are you free to talk with the other scientists on scientific ideas that come up?

A. Yes. Reynolds scientists are expected to talk to each other and to communicate on a regular basis. They are free to talk with other scientists not only internally, but also with scientists outside of Reynolds, including scientists at universities and research institutes.

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Q. Are you and your colleagues at Reynolds free to write memos?

A. Yes.

Q. Do scientists have to get permission to write a memo?

A. No.

Q. Are there any prohibitions or constraints about what scientists at Reynolds can say or can write?

A. No.

Q. Are there any prohibitions about using certain words, like "cancer" or "addiction"?

A. No.

Q. Do you always agree with the contents or ideas contained in memos written by your colleagues?

A. No.

Q. If a scientist writes something that you or other executives disagree with, do they lose their jobs?

A. No.

Q. Are you surprised that you sometimes read memos containing bad ideas, or something with which you disagree?

A. No.

Q. Why not?

A. Reynolds has employed thousands of scientists since the 1950s. We do not tell our scientists how to think. We expect our scientists to be creative and to develop ideas. That is part of what an R&D organization is all about. In the process of encouraging people to come up with ideas, you are going to get some good ideas, you are going to get some bad ideas,

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and you are going to get some that at the time you are not sure whether they are good or bad.

Q. Does the fact that someone writes something in a document mean that Reynolds acted on the document?

A. No.

Q. Does the fact that someone writes something in a document mean that the document represents Reynolds' corporate position regarding an issue?

A. No.

K. R.J. REYNOLDS' PUBLICATION PROCEDURES

Q. In addition to having intellectual freedom of thought, during your tenure, did the scientists at Reynolds have freedom to publish and make presentations on their research?

A. Yes. It is not just that our scientists had the freedom to publish, but rather they were encouraged and expected to publish. We wanted our scientists to publish good research that furthers scientific knowledge and was a significant contribution to science.

Q. Throughout your tenure, did Reynolds have a procedure for scientists to follow if they wished to submit something for publication, or make a scientific presentation?

A. Yes.

Q. What was the procedure?

A. When a scientist at Reynolds wanted to publish something, he or she would write up a detailed manuscript exactly the way that they intend to submit it to a scientific journal. The manuscript was then reviewed by at least two scientists in the department who had detailed, intimate knowledge of that type of science and that type of experiment. These reviewers delved into the details, critiqued the submission very rigorously, and decided whether or not

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it was a first-quality piece of work. Any flaws in the manuscript or research must be addressed before the review would continue. The next part of the process was review by R&D management. Management looked at the overall quality of the manuscript and ensured that no trade secret or proprietary information would be revealed by publication. Ultimately the manuscript would to the Executive Vice President of R&D for review and the final decision on publication.

Q. What type of publications would not be approved?

A. There were several areas of proprietary information in which we would not publish. One notable area is cigarette design. We are in a very competitive industry and how we design cigarettes for risk reduction or other purposes is extremely competitive and sensitive. If we do develop a new cigarette design that has real potential, we are more likely to patent that information to give us the intellectual property rights.

Q. Under this procedure, have Reynolds scientists authored publications that are available in the open, scientific literature?

A. Yes. In fact, Reynolds has published more than eight hundred manuscripts since 1980.

Q. And have Reynolds scientists made presentations at open, scientific conferences on their research?

A. Yes. Since 1980, we have made over eight hundred scientific presentations at scientific conferences like the Society of Toxicology and the TSRC, among other places.

Q. How do you know this information?

A. Our R&D librarian maintains a list containing this information. In addition, for many years, our corporate website has listed Reynolds' publications and presentations going back to 1984.

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Q. Have you prepared a summary chart at my request that lists examples of Reynolds' scientific presentations and publications over the past two decades in the fields of chemistry, biology and toxicology?

A. Yes. JD-067970 contains examples of our publications and presentations.

Q. With respect to this work that's been published by the Reynolds scientists, has the Surgeon General of the United States ever cited Reynolds' work?

A. Yes. The first Surgeon General's Report in 1964 cited to some scientific publications by Reynolds. Since that time, Reynolds' work has been cited in other reports of the Surgeons General, including in 1979, 1981, 1988, 1989 and 2000.

Q. Do you have any reason to believe that Reynolds' commitment to publishing and presenting its scientific research will end with your retirement?

A. No.

L. COMPENSATION OF SCIENTISTS AND ATTACKS ON CREDIBILITY

Q. I now want to discuss with you a very serious allegation that the Government has made specifically about you and your colleagues at Reynolds who have testified in litigation or regulatory proceedings. Have you testified in court for Reynolds before today?

A. Yes.

Q. Have you been accepted as an expert by State and Federal courts?

A. Yes.

Q. Do you testify in every case for Reynolds?

A. No.

Q. Now that you are retired, do you receive pension benefits?

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A. Yes.

Q. Are you getting paid anything extra for testifying for Reynolds in this case?

A. My expenses are being covered, but I am not receiving any payment.

Q. Did you ever receive payment above your normal salary for testifying for Reynolds?

A. No.

Q. Do you have any expectation, one way or the other, that you will be compensated or rewarded in any way for the actual content of what you say in court in this case?

A. No, I do not.

Q. Has that expectation been the same every time you have testified?

A. Yes, it has. I have never expected to be compensated or rewarded for what I say in testimony.

Q. Has the fact that you have testified – not what you have said, but that you have went above and beyond your everyday responsibilities at Reynolds – ever been recognized by Reynolds or your colleagues?

A. Yes, my colleagues at Reynolds are aware that I have testified and that fact has been mentioned on occasion by them, including in annual reviews or promotion recommendations. Such recognition has been very rare, though.

Q. Has the fact that your testimony is recognized on occasion affected in any way whatsoever the actual substance of your testimony in any proceeding?

A. Absolutely not. In every instance, I have testified truthfully and have never considered doing otherwise for any reason, let alone because of an asserted expectation of being rewarded.

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Q. Do you believe that any benefits you've received while being employed by Reynolds were because of what you said in litigation?

A. No.

Q. Has anyone ever informed you that the benefits you've received while at Reynolds were due to what you have said in litigation?

A. No.

Q. In addition to the promotions and annual reviews that you received in your 27 years with Reynolds, did you also have the opportunity to evaluate people who reported to you and make recommendations regarding their promotions?

A. Yes, many times.

Q. Did you also have the responsibility of making decisions regarding who would actually receive promotions in your department?

A. Yes, particularly in more recent years after I became a vice president in the Research and Development Department. Since October 2000, as the head of R&D, I had the ultimate decision making authority regarding all promotions within my department.

Q. Have other scientists for Reynolds testified in litigation or at regulatory hearings during your tenure?

A. Yes.

Q. In your experience as a supervisor, and more recently as someone responsible for making decisions regarding promotions, what impact, if any, does the fact that a scientist has testified for Reynolds have on their promotions, evaluations and compensation?

A. Reynolds' Research and Development Department is a scientific organization and our people are rewarded for being good scientists and conducting good scientific research. If

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they go above and beyond their job requirements as a scientist, then those actions may be recognized by management for that very reason: because they went above and beyond what is expected. Some examples of that would include coordinating scientific conferences, being an adjunct professor, or serving on the board of a scientific organization. But, any suggestion that we expect our scientists to say certain things in litigation is completely false. Any promotions or awards that are given to our scientists are based on merit and have nothing to do with the substance of what they say in litigation, or any other public forum.

Q. Thank you, Dr. Townsend. No further questions.

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